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# The Rodents of Libya
# Taxonomy, Ecology and Zoogeographical Relationships

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# Contents


| | Page |
|---|---|
| Acknowledgments | 1 |
| Introduction | 3 |
| Physical description of Libya | 6 |
| General features | 6 |
| The coastal plain | 7 |
| The coastal escarpment | 7 |
| Pre-Saharan or steppe | 7 |
| Hamadas | 8 |
| Sand seas | 9 |
| Serirs | 9 |
| Fesh-fesh | 10 |
| Depressions | 10 |
| Mountainous areas of the interior | 10 |
| The Cyrenaican Plateau | 11 |
| The Tripolitanian Gebel | 11 |
| Geology | 12 |
| Tripolitania and Cyrenaica | 12 |
| Fezzan | 13 |
| Volcanic activity | 14 |
| Climate | 14 |
| Libyan interior | 14 |
| Arid or desert type | 14 |
| Semiarid or steppe type | 15 |
| Mediterranean littoral | 16 |
| Coastal uplands | 17 |
| Additional meteorological data | 17 |
| Phytogeography | 18 |
| General features of the Saharan flora | 18 |
| Phytogeographic characteristics | 19 |
| Systematic composition | 19 |
| Endemism | 20 |
| Adaptation to the desert environment | 20 |
| The vegetative cover of Libya | 21 |
| Coastal plain | 21 |
| Cyrenaican Plateau | 22 |
| Tripolitanian Gebel | 23 |
| Saharan steppe | 23 |
| Sand seas, hamadas, and serirs | 23 |
| Depressions or sebchets | 24 |
| Oases | 24 |
| The grass cover of Libya | 25 |
| Mammalian Faunal Areas | 26 |
| Mediterranean Faunal Area | 27 |
| Saharan Steppe Faunal Area | 30 |
| Saharan Desert Faunal Area | 30 |

Page

Speciation and geographical variation . . . . . 34
Geographic variation in response to selective factors of the habitat . . 35
Modes of speciation . . . . . 36
Sympatric speciation . . . . . 37
Geographic speciation . . . . . 39
Clinal variation . . . . . 39
Geographic isolates . . . . . 40
Zoogeographical considerations . . . . . 44
Effects of the Pleistocene on the dispersal of Saharan and Libyan rodents . . . . . 44
Zoogeographical relationships of the rodents of the Sahara and Southwest Asia . . . . . 53
Conclusions . . . . . 61
Systematic treatment . . . . . 62
Plan of treatment . . . . . 62
Gazetteer of principal collecting localities . . . . . 67
Family Cricetidae . . . . . 69
Subfamily Microtinae . . . . . 69
Genus *Microtus* Schrank . . . . . 69
*Microtus mustersi* Hinton . . . . . 69
Subfamily Gerbillinae . . . . . 73
Genus *Gerbillus* Desmarest . . . . . 73
*Gerbillus aureus aureus* Setzer . . . . . 87
*Gerbillus aureus favillus* Setzer . . . . . 89
*Gerbillus aureus nalutensis*, new subspecies . . . . . 90
*Gerbillus eatoni eatoni* Thomas . . . . . 95
*Gerbillus eatoni inflatus*, new subspecies . . . . . 97
*Gerbillus eatoni versicolor*, new subspecies . . . . . 98
*Gerbillus gerbillus acruginosus*, new subspecies . . . . . 103
*Gerbillus gerbillus discolor*, new subspecies . . . . . 106
*Gerbillus gerbillus gerbillus* (Olivier) . . . . . 109
*Gerbillus gerbillus latastei* Thomas and Trouessart . . . . . 110
*Gerbillus gerbillus psammophilous*, new subspecies . . . . . 112
*Gerbillus pyramidum hamadensis*, new subspecies . . . . . 118
*Gerbillus pyramidum tarabuli* Thomas . . . . . 121
*Gerbillus amoenus vivax* (Thomas) . . . . . 125
*Gerbillus campestris brunnescens*, new subspecies . . . . . 133
*Gerbillus campestris dodsoni* (Thomas) . . . . . 136
*Gerbillus campestris haymani* Setzer . . . . . 139
*Gerbillus campestris patrizii* (de Beaux) . . . . . 141
*Gerbillus campestris wassifi* Setzer . . . . . 143
*Gerbillus grobbeni* Klaptocz . . . . . 146
*Gerbillus henleyi henleyi* (de Winton) . . . . . 147
*Gerbillus kaiseri* Setzer . . . . . 149
Genus *Pachyuromys* Lataste . . . . . 153
*Pachyuromys duprasi natronensis* de Winton . . . . . 153
Genus *Meriones* Illiger . . . . . 157
*Meriones caudatus amplus*, new subspecies . . . . . 165
*Meriones caudatus caudatus* Thomas . . . . . 169
*Meriones caudatus confalonierii* de Beaux . . . . . 172

Page

Family Cricetidae—Continued
Subfamily Gerbillinae—Continued
Genus *Meriones* Illiger—Continued
*Meriones caudatus luridus*, new subspecies . . . 173
*Meriones crassus tripolius* Thomas . . . 176
*Meriones libycus auratus*, new subspecies . . . 183
*Meriones libycus azizi* Setzer . . . 185
Genus *Psammomys* Cretzschmar . . . 187
*Psammomys obesus obesus* Cretzschmar . . . 190
*Psammomys obesus tripolitanus* Thomas . . . 192
*Psammomys vexillaris vexillaris* Thomas . . . 192
Family Spalacidae . . . 194
Genus *Spalax* Güldenstaedt . . . 194
*Spalax ehrenbergi aegyptiacus* Nehring . . . 194
Family Muridae . . . 199
Genus *Rattus* Fischer . . . 199
*Rattus norvegicus* (Berkenhout) . . . 199
*Rattus rattus* (Linnaeus) . . . 200
Genus *Mus* Linnaeus . . . 203
*Mus musculus* Linnaeus . . . 203
Genus *Acomys* Geoffroy . . . 208
*Acomys cahirinus viator* Thomas . . . 208
Family Gliridae . . . 212
Genus *Eliomys* Wagner . . . 212
*Eliomys quercinus cyrenaicus* Festa . . . 214
*Eliomys quercinus denticulatus*, new subspecies . . . 216
*Eliomys quercinus tunetae* Thomas . . . 219
Family Dipodidae . . . 220
Genus *Jaculus* Erxleben . . . 220
*Jaculus deserti favillus* Setzer . . . 224
*Jaculus deserti fuscipes*, new subspecies . . . 226
*Jaculus deserti rarus*, new subspecies . . . 228
*Jaculus deserti vastus*, new subspecies . . . 230
*Jaculus jaculus arenaceous*, new subspecies . . . 234
*Jaculus jaculus collinsi*, new subspecies . . . 236
*Jaculus jaculus cufrensis*, new subspecies . . . 238
*Jaculus jaculus tripolitanicus*, new subspecies . . . 240
*Jaculus jaculus whitchurchi*, new subspecies . . . 242
*Jaculus orientalis orientalis* Erxleben . . . 244
Genus *Allactaga* Cuvier . . . 248
*Allactaga tetradactyla* (Lichtenstein) . . . 248
Family Hystricidae . . . 251
Genus *Hystrix* Linnaeus . . . 251
*Hystrix cristata* Linnaeus . . . 251
Family Ctenodactylidae . . . 252
Genus *Ctenodactylus* Gray . . . 252
*Ctenodactylus gundi gundi* (Rothman) . . . 254
*Ctenodactylus gundi vali* Thomas . . . 259
Literature cited . . . 260
Plates . . . 265

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## Introduction

Libya is a vast expanse of semiarid and arid desert of variable topography located in North Africa bordering on the Mediterranean Sea. A large portion of the Libyan coastline follows the broad indentation of the Gulf of Sirte. Libya is bordered on the east by Egypt (United Arab Republic), on the southeast by the Sudan, and on the west by Tunisia and Algeria. The republics of the Chad and Niger form various portions of the southern marginal limits. The latitudinal limits range from 19° north latitude at the extreme southeastern portion to 33° north latitude at its northern extremity in Cyrenaica. Longitudinally, Libya lies between 9° and 25° east longitude. This large country comprises approximately 680,000 square miles of primarily desert terrain and is divisible into three political provinces. The province of Cyrenaica (approximately 330,000 sq. mi.) encompasses roughly the entire eastern half of Libya, and the provinces of Tripolitania (approximately 136,000 sq. mi.) and Fezzan (approximately 213,000 sq. mi.) include the northwestern and southwestern quadrants respectively.

The surface configuration of Libya is quite varied with elevations ranging from below sea level in the Sebchet el Gheneien near Gialo and in the depressions surrounding Giarabub and Bahr el Tubat to over 10,000 feet above sea level in the outliers of the Tibesti Mountains of extreme southwestern Cyrenaica. In Libya, elevation tends to increase gradually from north to south, the deserts of the interior generally much higher than the coastal areas; a similar gradient in elevation is seen in an east-west transect, the eastern portion appreciably lower than the west. Abrupt local and regional changes in relief occur throughout Libya owing to the juxtaposition of low-lying plains, high plateaus, and mountain complexes.

The pattern of vegetative cover in Libya follows rather closely the physiographic features. The flora of the low-lying coastal plain is particularly distinct from that of the pre-Saharan (steppe) and Saharan zones of the interior. Likewise the Cyrenaican Plateau, because of its higher elevation and more abundant rainfall, has a flora unlike that of the coastal plain and interior deserts.

Permanent vegetative cover of the Saharan interior of Libya is sparse, and in large portions of the hamadas, serirs, and sand seas, it is entirely lacking. Where vegetation occurs in these interior deserts, it is usually either sporadic and tends to be localized in sandy depressions of the hamadas, or occurs as narrow fringes bordering the

larger wadis (dry watercourses). Vegetation also occurs sparingly along the margins of the sand seas. Some of the mountainous complexes support scattered growths of grasses, and others are almost devoid of vegetation. The oases of the Libyan Sahara support extensive groves of date palms and other agricultural crops and appear as verdant areas in the midst of their barren surroundings.

The climate of most of Libya is typically Saharan and extremely arid but is more humid in the coastal areas. As a result of their higher elevations and greater amounts of rainfall, the Tripolitanian Gebel and the Cyrenaican Plateau are local exceptions and have cooler climates.

Explorations in Libya date from the end of the 18th century, but zoological information did not begin to accumulate until the end of the 19th century. Among the earliest publications relating to the rodent fauna of Libya and adjacent countries are those of Yarrel (1831), Loche (1867), Lataste (1881 and 1887), Nehring (1897), and Sordelli (1899). The 20th century marked the beginning of any real definitive studies of Libyan rodents. Most prominent among these workers during the early part of this century are: Thomas (1902–1925), Klaptocz (1909), Andreucci (1914), Ghigi (1920), Festa (1921 and 1925), Hartert (1923), Hinton (1926), and de Beaux (1928, 1932, and 1938). More recently Zavattari (1934 and 1937), Heim de Balsac (1935), Rode (1948), and Toschi (1951 and 1954) have published papers dealing with various aspects of the Libyan rodent fauna. Setzer (1956 and 1957) is the most recent worker on Libyan mammals.

Prior to the present study, relatively few specimens of Libyan mammals were available, and the systematic composition and distribution of the rodent fauna were accordingly poorly known. Specimens collected by the Whitaker Expedition to Tripolitania and the Fezzan in 1901 (reported by Thomas in 1902), those collected by de Beaux's expeditions to Giarabub and Cufra in 1928 and 1932, and those obtained by Toschi in 1951 and 1954, constituted the most significant collections of Libyan rodents prior to 1955.

This study of Libyan rodents is based primarily on specimens obtained by the author during the period from October 1961 to July 1962.

Field work consisted of approximately 10 months of intensive collecting in various parts of the three provinces of Libya. During this period efforts were made to obtain adequate series of representative rodents from all types of habitats.

The duration of each collecting trip ranged from 1 week to 3 months. One to 14 days were spent at each collecting site. The majority of specimens were obtained by using approximately 200 museum special

traps per night, baited with moistened oatmeal and set in a conventional fashion. Occasionally, rattraps were used to take large rodents, such as jirds (*Meriones*) and sand rats (*Psammomys*). In a few instances jirds (*Meriones*), gerbils (*Gerbillus*) and house mice (*Mus*) were purchased from local residents of the oases. Mole rats (*Spalax*) were obtained using Macabee gopher traps. Diurnal rodents, such as sand rats (*Psammomys*) and gundis (*Ctenodactylus*), were shot with a 16-gauge shotgun, using number 9 shot or a .32-caliber auxiliary barrel in the 16-gauge shotgun, using .32-caliber shells loaded with dust shot. The most effective method for collecting sand rats (*Psammomys*) involved shooting them along the roadside while riding on the front of the Land Rover.

Actual field work consisted of 16,175 trap nights which yielded in excess of 3,100 specimens, of which some 1,758 were retained as specimens. One hundred sixty-five days and nights were spent in the field, of which 124 were spent collecting.

Significant collections were also obtained by Henry W. Setzer in the fall of 1955, while engaged in a preliminary survey of Libyan mammals, and again in the spring of 1961, while on a trans-Saharan trip to the Tibesti Mountains. Additional specimens were collected by James H. Shaw, who accompanied the author on a collecting trip to northern Cyrenaica in the spring of 1962. Additional specimens were borrowed from the British and Paris museums for comparative purposes. The present study is thus based on a total of 2,026 specimens representing 28 species and 48 subspecies.

Many areas in Libya are still not represented by specimens, however, and many of the conclusions regarding the systematics and distribution of certain taxa are thus conjectural. For example, the occurrence in the Coastal Plain Province of several subspecies of *Gerbillus eatoni* Thomas is not consistent with recognized concepts of speciation. When specimens become available from more localities on the coastal plain and permit a more comprehensive study, the Coastal Plain Province will probably prove to be divisible into a number of subprovinces, each having a typical rodent fauna.

The present study is the first attempt to provide a comprehensive treatment of the taxonomy and distribution of Libyan rodents based upon actual specimens and field experience. This account is not to be regarded as a final work on the systematics and distribution of Libyan rodents but is, instead, a progress report limited to information available at the present time. Much remains to be learned about speciation and distribution of the Libyan rodent fauna, and it is hoped that this paper will serve as a point of departure for future research.

## Physical Description of Libya

### General Features

Libya is divisible into several rather broad physiographic elements. These include the coastal plain adjacent to the Mediterranean Sea, the coastal escarpment delineating the inland margin of the coastal plain, the broad zone of sand and gravel plains of the pre-Saharan region south of the coastal escarpment, and the hamadas, serirs, and sand seas of the Saharan interior. In many areas, isolated mountain complexes, escarpments, and local rocky outcroppings are widespread and form a large part of the desert landscape. In other areas, near the coast and in the interior, large, dry watercourses (wadis) dissect the otherwise featureless plains. These wadis are a typical feature of the Libyan Sahara and, in many areas, provide the only visible contrast in an otherwise monotonous landscape. In northern Cyrenaica, the deep canyons and high tablelands of the Cyrenaican Plateau, and in Tripolitania, the high valleys and rocky headlands of the Gebel Nefusa form physiographic features differing markedly from the low-lying surrounding terrain.

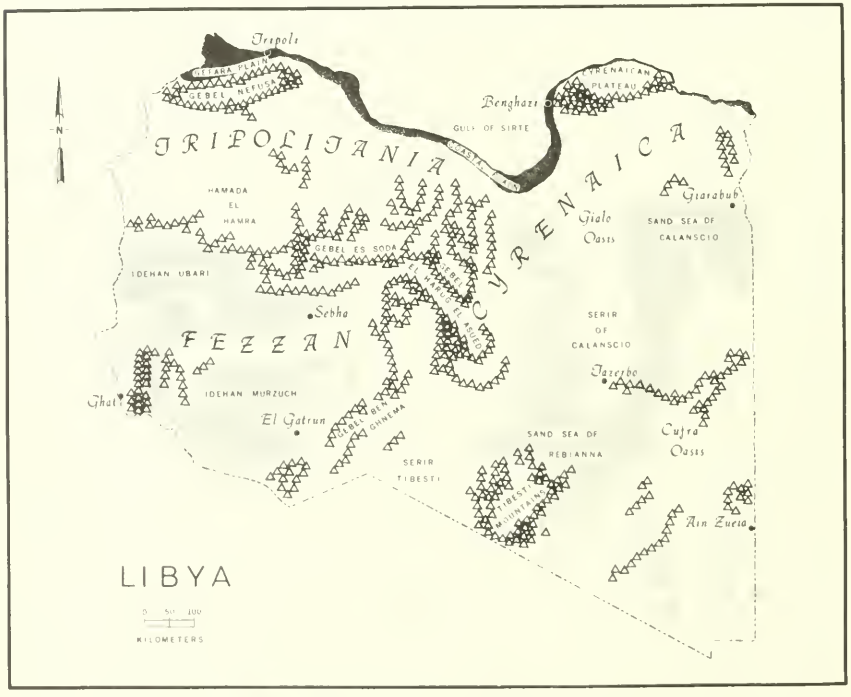


FIGURE 1.—Physical features of Libya.

### The Coastal Plain

The Libyan coastal plain varies in width from a few hundred meters in some places in northern Cyrenaica to perhaps 50 or 60 kilometers at its widest portion in northwestern Tripolitania. This plain stretches uninterruptedly across northern Tripolitania and along the southern margins of the Gulf of Sirte, but in northern Cyrenaica, it is markedly reduced, and in some places completely obliterated, owing to the encroachment of the escarpments of the Cyrenaican Plateau and Gebel Achdar. In most areas the coastal plain is slightly elevated above the sea, and extensive sandy beaches occur near the coastline. Occasionally, larger wadis emerging from the coastal escarpment cause local irregularities in the surface of the coastal plain, but normally it is relatively flat and rather featureless. In many areas along the Gulf of Sirte, huge coastal dunes extend for great distances along the seaward margins. Smaller, more localized dunes occur near the coastal escarpment in the broad coastal plain of northwestern Tripolitania.

In northern Tripolitania, where the coastal plain is frequently 40 or 50 kilometers in width, the higher, more inland portions are gently undulating and support extensive olive groves and vineyards. Near Misurata and Tauorga, along the western margin of the Gulf of Sirte, the coastal plain is also quite wide and is partially submerged along the seaward portions, forming an extensive salt marsh known as the Sebchet el Tauorga.

### The Coastal Escarpment

A coastal escarpment varying in height from a few meters to a thousand meters is usually present, separating the coastal plain from the higher deserts of the interior. These escarpments reach their most impressive size in northern Cyrenaica and northwestern Tripolitania where they mark the northernmost limits of the Cyrenaican Plateau and the Tripolitanian Gebel (Gebel Nefusa). In many areas near the Gulf of Sirte, the coastal escarpments are reduced to a line of indistinct cliffs on the inner margin of the coastal plain. In other areas the escarpment is lacking entirely, and the coastal plain grades almost imperceptibly into transitional desert farther inland.

In some areas of Cyrenaica, the lower terraces of the coastal escarpment are sometimes a hundred meters above the level of the sea and form rocky headlands along their seaward margins.

### Pre-Saharan or Steppe

A broad belt of pre-Saharan desert is typical of vast areas of Libya located between the humid Mediterranean littoral and the truly

Saharan desert of the interior. These transitional deserts are generally irregular in profile and are frequently dissected by numerous dry watercourses (wadis) which drain northward into the Mediterranean. Some of the larger wadis, such as the Wadi Bey, Wadi Soffegin, and Wadi Zemzem of northern Tripolitania, form characteristic topographic features with their deep canyons, boulder-strewn slopes and broad, eroded bottoms. Gravel plains (hamadas) of small extent are not uncommon in these marginal deserts and are frequently interspersed with mud pans reminiscent of playas. Sandy plains and dune areas are present also but are usually sporadic and localized.

Farther southward, in the Sahara proper, these gravel plains and sandy areas are of much greater extent and form discrete physiographic entities which are known regionally by specific names, such as the Hamada el Hamra of southwestern Tripolitania, the Idehan Murzuch of the Fezzan, and the vast Sand Sea of Calanscio of eastern Cyrenaica.

### Hamadas

The terrain of most of the interior of Libya is typically Saharan, being composed primarily of vast areas of pebble deserts or "hamadas" interspersed among desolate sand seas or "ramleh." Mountainous areas or "gebels" and rocky scarps frequently interrupt the otherwise featureless landscape. Contrary to popular belief, these hamadas are the dominant physical feature of the Sahara, the sandy plains (serirs) and sand seas forming probably less than 20 percent of the total land area.

The hamada desert is a distinct physiographic type characterized by extensive gravel plains formed of pebbles of various sizes lying on top of a rather firm substrate. The size of the individual particles varies considerably in the different types of hamada, ranging from small pebbles to rather coarse rock-strewn surfaces. Regional differences in the character of the hamadas are sometimes striking. For example, the Hamada el Hamra of southwestern Tripolitania is of the fine-grained type and provides probably the smoothest, most featureless surface of any of the Libyan hamadas. The hamadas farther south are much coarser in composition, especially those surrounding the volcanic extrusions of the Gebel el Harug el Asued of central Libya and the numerous localized hamadas which occur between the oases of Traghen, Umm el Araneb, Meseguin, and Zuila in the Fezzan. Some of these Fezzanese hamadas could be likened to vast boulder fields.

The overall coloration of these hamadas is generally gray, but local variations of red, yellow, and brown occur. The coarse hamadas associated with volcanic extrusions are normally dark gray or even

black. The majority of these hamadas are usually flat and lack any contrasting physical features. The coarser hamadas tend to have more undulating surfaces, and occasionally local mounds or rocky outcroppings are present. In general, the hamadas show little change in relief, being of comparable elevation throughout their full expanse. Some of the larger hamadas stretch uniterruptedly for several hundred kilometers and in this respect are remote and desolate.

### Sand Seas

Although occupying a smaller total land area than the hamadas, the sand seas or "ramleh" are one of the most distinctive physical features of the Sahara. They occur sporadically in the interior of Libya where they are contiguous with the hamadas and frequently interdigitate with them. Small and localized sandy plains and dune areas are present in the Libyan interior, but the principal sand seas are represented by the Sand Sea of Calanscio of east-central Cyrenaica; the Sand Sea of Rebianna, which is continuous with the latter and extends to the northern outliers of the Tibesti Mountains of extreme southern Cyrenaica; the great Idehan Murzuch of the southern Fezzan and the Idehan Ubari of the southwestern Fezzan, which includes virtually all of the region south of the Hamada de Tinrhert to the Wadi Irauen and Wadi el Agial and includes the area from Sebha west to the Algerian border. The "Ramleh Zellaf," immediately north of Sebha, is the easternmost portion of this immense sand sea.

Normally these sand seas have gently undulating surfaces, but frequently extensive dune areas occur. The individual dunes vary in size, but some reach almost mountainous proportions, sometimes exceeding 250 meters in height. Some of the dunes of the Sand Sea of Calanscio are reputed to be even higher. In many areas the dunes are relatively stable, but in others they are constantly changing shape and shifting their positions. Firmness of the sand varies markedly from place to place and according to the time of day, being firmer during the cool, early morning hours than in the hotter periods of midday.

### Serirs

Occasionally, bedrock is covered with a veneer of sand and gravel of varying depth. When these areas are quite extensive, they are known as "serirs" and differ from typical sand seas by their more uniform surfaces and the coarser, more heterogeneous nature of the individual particles. The Serir of Calanscio, of central Cyrenaica, typifies this physiographic type and includes the vast plain extending from Gialo Oasis south to Tazerbo Oasis and extending from the

285-134 O—68——2

western margins of the Sand Sea of Calanscio to the eastern limits of the Gebel el Harug el Asued.

### Fesh-fesh

In some areas of Libya, the surface layer is composed of extremely soft and unstable materials similar in texture to silt or loess deposits. These "fesh-fesh" deserts are usually restricted in size but occasionally cover large areas. This type of desert is most abundant in areas of low elevation and along the margins of depressions such as the Sebchet el Gheneien, north of Gialo, and Giarabub Oasis. The hamadas and serirs sometimes grade imperceptibly into local "pockets" of fesh-fesh. This intercalation of serir and fesh-fesh occurs frequently in the western part of the Serir of Calanscio near the eastern limits of the Gebel el Harug el Asued.

### Depressions

The depressions associated with Giarabub Oasis and Bahr el Tubat and the Sebchet el Gheneien north of Gialo are physiographically distinct from the surrounding terrain. These depressed areas are located great distances from the sea but are below sea level. These low-lying areas of Cyrenaica represent the westernmost limits of the great east-west depression which links together Siwa Oasis, the Qattara Depression, and the Wadi Natroun of northern Egypt. Most of these low-lying areas have extensive salt marshes in their lowest portions, and the larger depressions frequently contain saline lakes of considerable size. Bahr el Tubat, east of Giarabub, is typical of this type of shallow salty lake, which has thick encrustations of salts along its margins, which in some places extend several hundred meters from the waters edge. Smaller saline lakes occur in the oases of Tazerbo, Cufra and Bzema of southern Cyrenaica, and isolated pockets, containing some open water with marginal encrustations of salt, are of sporadic occurrence in the central Fezzan.

### Mountainous Areas of the Interior

Scattered throughout the interior of Libya are numerous rocky escarpments, large wadis with steep rocky margins, and extensive desert mountain ranges (gebels). Most of the mountainous areas of the Libyan hinterland are characteristically rugged with sharp contours and have broad canyons with angular rock formations and precipitous walls. Isolated rock formations, some of which reach huge proportions, occur irregularly throughout the Fezzan and southern Cyrenaica.

The larger mountain complexes of Libya are volcanic extrusions and are surrounded by great expanses of coarse, boulder-sized talus.

The Gebel es Soda and the Gebel el Harug el Asued of central Libya are mountains of this type. Both of these gebels have been regarded as the "Black Gebel" because of the color of the lava of which they are composed. Other mountain complexes of the Libyan interior which reach sizable proportions include the Acacus Mountains near Ghat in the extreme southwestern Fezzan and the Gebel Archenu, Gebel Uweinat, and the outliers of the Tibesti Mountains in southern Cyrenaica. In many areas of the eastern Fezzan and southern Cyrenaica, rocky formations are present in the form of buttes and mesas in the midst of hamadas or sand seas. Cufra Oasis is surrounded by a complex of steep-sided gebels, and Bzema Oasis, which is located deep within the Sand Sea of Rebianna, is situated at the base of an imposing monolith.

### The Cyrenaican Plateau

The massif of the Cyrenaican Plateau of extreme northern Cyrenaica, with its high rolling slopes and deep canyons, differs strikingly from all other physical features of Libya. The Cyrenaican Plateau proper encompasses the region of Cyrenaica from Benghazi in the west to Martuba in the east. Its southern terminus is near El Mechili where it grades imperceptibly into the inland hamada. The Gebel el Achdar, which comprises the northernmost and highest portions of the plateau, extends almost to the Mediterranean Sea where it terminates in a rocky terraced escarpment. These escarpments provide a sharp contrast in relief to the low-lying hamadas and coastal plain. In many places the coastal "gebel" encroaches onto the coastal plain causing its virtual elimination. Deep canyons with rugged precipitous slopes have their origin in the interior of the plateau and dissect the coastal escarpment.

The highest point in the plateau is 2,844 feet above sea level located on the Gebel el Achdar between Slonta and El Faidia. The higher portions of the Cyrenaican Plateau have characteristic broad, rolling slopes, and the canyons are less rocky and have less precipitous margins than those nearer the coast. Some areas of the plateau are almost flat and allow sizable agricultural endeavors. The Barce Valley, in the western part of the plateau, is a basin of internal drainage and is unique in Libya in this respect. During periods of unusually high rainfall, fresh water accumulates in the bottom of the valley to a depth of several feet and thus forms a rather sizable lake.

### The Tripolitanian Gebel

The Gebel Nefusa of northwestern Tripolitania is less clearly defined by discrete physical elements. It includes the high tablelands extending roughly from the Tunisian border in the west to the vicinity

of Cussabat near the western edge of the Gulf of Sirte. The southern portions of the gebel grade imperceptibly into the hamadas and transitional desert north of the Hamada el Hamra. A decreasing gradient in elevation runs from north to south, thus the highest portions of the gebel are on its northern margins where it terminates abruptly in the coastal escarpment.

The average elevation of the Gebel Nefusa exceeds 2,000 feet and in many areas approaches 3,000 feet. The highest point in the gebel (3,176 feet above sea level) is located between Gharian and Beni Ulid.

South of the rugged coastal escarpment the interior of the Gebel Nefusa transforms into gently, undulating tablelands with broad valleys and smooth slopes. Several major and numerous lesser wadis have their origins in the interior of the Tripolitanian Gebel. Chief among these are the Wadi Soffegin, which drains eastward into the Gulf of Sirte; the Wadi Tmasia, which has its origin in the gebel north of the Wadi Soffegin; and the Wadi Caam, which arises in the northeastern portions of the gebel and empties into the Mediterranean Sea east of Tripoli.

## Geology

### Tripolitania and Cyrenaica

This discussion of the major geological features of Libya is based on information given by Raymond Furon in "Geology of Africa" (1960).

A succession of Mesozoic and Paleozoic sandstones, ranging from the Permian to the Jurassic, outcrops at El Azizia on the Gefara Plain south of Tripoli. These systems are continuous with those of Tunisia.

The "Continental Intercalaire," of Triassic, Jurassic, and Cretaceous age, outcrops at the base of the coastal escarpment near Homs, Tripolitania, and extends westward nearly to the Tunisian border. This formation is composed of sandstones and clays with numerous plant remains, including silicified wood. The "Continental Intercalaire" extends south to the Tibesti Mountains, but in southern Tripolitania and the northern Fezzan, it is overlain by the Cretaceous marine limestones of the Hamada el Hamra and the Hamada de Tinrhert.

Marine transgressions invaded Tripolitania and Cyrenaica during the Cretaceous and at successive periods of the Tertiary. The deposits of the Cretaceous form the Hamada el Hamra and the Hamada de Tinrhert in Libya and the Tademait Plateau of the Algerian Sahara. These marine limestones are highly fossiliferous, containing a variety of marine organisms (corals, nerineas, and radiolarians), and extend south to the cliffs on the northern margin of the Fezzan Cuvette. To the east they are overlain by Tertiary deposits.

The Eocene transgression outcrops widely north and east of the Gebel es Soda and also appears near the coast on the Gebel el Akhad east of Benghazi. At El Fogaha, south of the Gebel es Soda, and on the Gebel el Achdar near Derna, the succession is complete, ranging from sediments of lower Eocene to upper Eocene.

Another transgression advanced to the Tibesti Mountains during the middle Eocene. These sediments, comprising 200 meters of limestone overlying the Paleozoic sandstones or resting directly upon the Pre-Cambrian, represent the Sirtica Trough, whose shorelines are found today at a height of 600 meters above sea level on the northern outliers of the Tibesti mountains.

Oligocene sediments indicate a deep gulf south of the Gulf of Sirte, which did not reach as far south as that of the Eocene.

The Miocene Sea included parts of Cyrenaica, and some lower Pliocene beds are found at Agedabia near the southeastern margins of the Gulf of Sirte.

### Fezzan

The geological structure of the Fezzan is relatively simple, being primarily a large cuvette (basin) of Nubian Sandstone (Cretaceous) overlying the Paleozoic. The Fezzanese cuvette is divisible into two large structural components: a southern synclinal zone which is an extension of the covering of the Ahaggar Mountains of southeastern Algeria and the Tibesti Mountains of the northern Chad, and a northern zone consisting of the Cretaceous Hamada de Tinrhert in the west and Eocene sediments in the east. Extensive volcanic extrusions rest upon portions of the northern zone.

The morphology of the western Fezzan is determined by a large east-northeast west-southwest anticline, which is connected in the southwest to another anticlinal zone near Ghat. This anticline extends from north of Serdeles to north of Edri. Farther west, it grades into the Fezzan synclinal cuvette and forms an artesian basin. The northern and southern limits of the anticline outcrop, respectively, as south-facing escarpments near El Hasi north of Edri, and as north-facing escarpments in the southern parts of the Wadi es Sciati.

In the western Fezzan, geological succession generally runs from Devonian to Lower Cretaceous and includes fossiliferous limestone, sandstones, and marls containing brachiopods, crinoids, and silicified wood.

The northeastern Fezzan is composed of Cretaceous rocks which disappear beneath Tertiary deposits farther east. Farther south, strata range from Pre-Cambrian to Cretaceous, but Paleozoic sediments are dominant.

Near Murzuch the Cretaceous Nubian Sandstone outcrops, forming the Murzuch Cuvette. The "Murzuch Limestones" (Cretaceous) form a series of limestone plateaus of lacustrine origin and contain gastropods. The plateaus are deeply eroded and are overlain by deep Quaternary deposits.

East of the basaltic Gebel el Harug el Asued, marine deposits are covered by the "Continental Terminal," which contains the remains of saurians, tortoises, fishes, and silicified woods.

The Gebel Uweinat is a mountain massif located near the Libyan, Egyptian, and Sudanese borders. Basally, it is formed of middle Pre-Cambrian crystalline schists, which have been intruded by granite, which forms the greater part of the Gebel. Following magmatic activity, a basal layer of Carboniferous sandstones was deposited, followed by several layers of continental sandstones containing silicified wood.

### Volcanic Activity

Volcanic activity occurred in three regions of Libya: the Gebel Gharian (Gebel Nefusa) south of Tripoli, the Gebel es Soda south of Socna, and the Gebel el Harug el Asued of southeastern Tripolitania and the northeastern Fezzan. These eruptions began in the Oligocene and continued until the Recent. Volcanic extrusions of the Gebel el Harug el Asued cover an area of 25,000 square kilometers and are represented by two major basaltic divisions. The first eruptions inundated the Eocene Plateau and today form an extensive lava field. A plateau of scoriaceous basalt of more recent origin occupies the center of the massif. The most recent basaltic flows have been deposited by volcanic cones, which still persist but are inactive. At present, there is no volcanic activity in any of these areas in Libya.

## Climate

### Libyan Interior

Two climatic subdivisions of the Libyan interior can be recognized: an arid or desert type, and a semiarid or steppe type.

### Arid or Desert Type

The Saharan portion of Libya is typical of the low latitude desert as regarded by Trewartha (1937), and unless stated otherwise, the following meteorological data relating to Libya was obtained from this source.

In the true Saharan portions of Libya, rainfall is always meager and extremely variable from year to year. In these areas, the variability of rainfall shows a 40+ percent departure from the normal, so it is meaningless to speak of a "typical" rainfall curve for the Libyan Sahara. Many areas in the interior of Libya receive less than one inch

of rain per year, and some parts of the Fezzan receive no rainfall at all, sometimes extending over many years.

Most precipitation results from violent convectional showers, which usually are limited to small areas. During the winter, there are occasional widespread rains of a cyclonic rather than convectional origin in the northern portion of the Libyan Sahara.

Skies are most frequently clear in the Libyan interior, particularly during the winter months (over much of the Sahara, December and January have a cloudiness of only 1/10).

Relative humidity is almost always low in the Saharan interior of Libya (12–30% for the midday hours), and evaporation is extremely high. Relative humidity as low as 2 percent, with temperatures of 100° F., has been recorded from the Egyptian Sahara, and doubtless similar conditions prevail in the Libyan Sahara. Even though the desert air is physiologically dry and does not approach saturation, absolute humidity is quite high because the hot desert air contains a considerable quantity of water vapor. Potential or actual evaporation, owing to high temperatures and low relative humidity, is excessive, often being 20 or more times the amount of precipitation.

In the Libyan interior it is the excessively high temperature in summer, rather than the cold winter temperature, which is responsible for the marked differences between the seasons. Dry air, cloudless skies, and bare, dry earth which produce relatively large temperature differences between the extreme months are also responsible for producing marked temperature variations within a 24-hour period.

During the high-sun period (summer) intense diurnal heat prevails. In the northern Sahara average daily maxima of 99° are followed by minima approximating 71° F. The highest air temperature (136.4° F) ever recorded anywhere in the shade under standard conditions was from El Azizia on the Gefara Plain south of Tripoli.

During the period of low-sun (winter), the days are still warm; the daily maxima usually average 60° to 70° F, but occasionally reach 80° F.

As is true with the rest of the Sahara, the sun largely controls local weather, resulting in a great deal of similarity between successive days.

The Saharan portion of Libya tends to be windy owing to the lack of obstruction of the moving air by the sparse vegetative cover. Also the rapid daytime heating of the lower air tends to convectional overturning. Nights are generally much less windy owing to the rapid, nocturnal convectional cooling of the surface air.

### Semiarid or Steppe Type

A region of low latitude steppe climate characteristically bounds the true Saharan portion of Libya to the north and is a transitional

belt between it and the humid climate of the Mediterranean littoral. These steppe areas in Libya are located on the margins of the trade winds and subtropical highs and are hence nearer to the humid climates. These areas are subjected to brief periods of winter, rain-bearing winds and their associated storms (the westerlies and their cyclonic storms), which cause them to be semiarid rather than arid.

At Benghazi, near the northern limits of the steppe region of Cyrenaica, no rainfall occurs during the months of June, July, and August, while December and January receive moderate amounts of rain. The steppe thus has almost all of its rain in the winter; the yearly total is 11.9 inches. The amount of precipitation varies from year to year from a recorded high of 24.3 inches to a low of 6.8 inches. Variability of rainfall is as great in the steppe region as in the true Saharan region. Because rain falls in showers of comparatively short duration, the weather is prevailingly sunny.

### Mediterranean Littoral

Most portions of coastal Libya have a Mediterranean or dry-summer subtropical climate. This climate, according to Trewartha, is characterized by three principal features: most precipitation in the winter season; warm to extremely hot summers and mild winters; and a high percentage of sunshine for the year, especially in the summer.

This Mediterranean climate in coastal Libya results from the dought-producing dry subtropical highs and tradelike winds on the south and the humid westerlies with their cyclonic storms on the north. As a result of the north-south shifting of these wind belts, these Mediterranean latitudes are joined at one season to the dry tropics and at the opposite season to the humid middle latitudes.

A uniform summer and a variable winter climate characterize these coastal areas. The climate of coastal Libya is transitional between the low-latitude steppe and desert and the cool, humid climates farther poleward.

It is the relative warmth of the Mediterranean Sea in winter, and the resulting low-pressure trough coincident with it, that attracts cyclonic storms in the winter season. The Mediterranean climate of coastal Libya is thus assured of a temperature regimen in which cold weather is largely absent. Winter months have average temperatures of between 40° F and 50° F, and the summer months between 70° F and 80° F, and mean annual ranges of 20° to 30° F are common. At Tobruch, on the northeastern Cyrenaican coast, the average January temperature is 56° F, while the average for July is 79° F. The average annual temperature at Benghazi on the coastal plain on on the Gulf of Sirte is 69° F with averages of 55° in January and 79° in August.

On the coastal plain, rainfall generally approaches 15 to 25 inches. The most characteristic feature of the climate of coastal Libya is the pronounced summer drought. If this amount of rain fell during the hot summers when evaporation is high, semiarid conditions would result. Coming as it does, however, in the cooler season, much less is evaporated, and Mediterranean climate of Libya can be described as subhumid rather than as semiarid.

A peculiarity of the climate of northern Tripolitania is the "Ghibli," a hot, desert wind which can cause temperatures to rise 30° to 40° F in both summer or winter. The "Ghiblis" raise the temperatures of the coastal plain well above 110° F, and sometimes the strong winds persist for several days carrying large quantities of dust into the coastal regions.

### Coastal Uplands

On the Cyrenaican Plateau and Tripolitanian Gebel, the summers are more moderate than those of the coastal plain. These plateau areas of Tripolitania and Cyrenaica, by virtue of their higher elevations, receive more rainfall than the surrounding areas. The Gebel Nefusa of northern Tripolitania receives a yearly average of 15 to 20 inches, most of this falling during a comparatively short winter period. The Cyrenaican Plateau has approximately 30 inches of rain distributed rather uniformly throughout the year.

### Additional Meteorological Data

Meteorological data obtained during field work in 1961 and 1962 provides supplemental information regarding the nature of the Libyan climate. In the Fezzan, during the period from Dec. 8, 1961, to Feb. 10, 1962, the daytime temperatures remained quite high with average maximum temperatures of 94° F (60°–117° F), but at night the temperature sometimes dropped below freezing, and the average minimum temperature was 36.1° F (27°–52° F). The temperature range for a 24-hour period sometimes exceeded 80° F. On the Gebel Nefusa of northwestern Tripolitania, for a 4-day period in early March 1962, the averages and extremes of the maximum and minimum temperatures were 91° F (83°–98° F) and 52.5° (45°–59° F). Averages and extremes of maximum and minimum temperatures at Cufra and Tazerbo oases for the period Apr. 1, 1962, to Apr. 17, 1962, were 98.4° F (83°–110° F) and 53.3° F (44°–68° F). During this same period the average relative humidity (taken in the evening) was 21 percent. For the periods of May 21 to May 25, June 1 to June 6, and from June 12 to June 21, 1962, the averages and extremes of the maximum and minimum temperatures and the average relative humidity, at various localities along the Cyrenaican and Tripolitanian

coastal plains, were, respectively: 113.7° F (108°–120° F), 62° F (53° F–74° F), and 74.2 percent. The above temperatures were taken during the "summer drought" on the coastal plain and probably represent the highest figures that would be obtainable during the year. Those from the interior were taken during the winter or low-sun period. Direct comparison of the data from the coastal plain with that obtained in the Fezzan and southern Cyrenaica would lack validity, as the two sets of data represent, respectively, the two extremes in the annual cycle of the Libyan climate.

The above data indicate that the Saharan interior is markedly more arid than the coastal region and undergoes greater temperature variation for any given 24-hour period.

## Phytogeography

### General Features of the Saharan Flora

The following information regarding the phytogeographic characteristics of the Sahara, including Libya, has been compiled from: Ozenda, "Flora du Sahara" (1958), which includes a comprehensive treatment of the flora of the northern and central Sahara; Zavattari, "Prodromo della Fauna della Libia" (1934), which treats briefly the regional Libyan flora; and Rattray, "The Grass Cover of Libya" (1960), in which Libya is divided into several regions according to the dominant type of grass cover.

According to Ozenda, the flora of North Africa, including the Sahara, comprises portions of two major floral empires: the Holarctic Floral Empire which includes all of Europe, North Africa (including the northern Sahara), and the greater part of Asia; and the Paleotropical Floral Empire which encompasses the central and southern Sahara and the remainder of Africa.

Coastal Libya falls within the Mediterranean Floral Region, and the Saharan interior of Libya belongs to the Saharo-Sindien Floral Region, which also includes northern Arabia and southern Iran, and extends as far east as the Sind Desert of West Pakistan. The flora of the Mediterranean Floral Region and the Saharo-Sindien Floral Region, and hence that of Libya, has most of its affinities with the Holarctic Floral Empire.

The Saharo-Sindien floral element is always dominant and contains three-fourths of all the plant species that occur in the Sahara. The Mediterranean affinities are naturally well developed along the northern margins of the Sahara in Libya. A Mediterranean element exists even in the mountains of the Central Sahara, but these plants are Mediterranean only in origin, not in their biology.

### Phytogeographic Characteristics

Ozenda summarizes the phytogeographic characteristics of the Saharo-Sindien Floral Region, which includes most of Libya, as follows:

(1) Great poverty of species (of the nearly 1,500 species of plants present, 1,000 occur in the Sahara). In the Sahara, there are 150 species of vascular plants per 10,000 square kilometers, as opposed to 1,000 to 2,000 in an area of comparable size in Europe. In the tropics the number of species increases to 3,000 or 4,000 per 10,000 square kilometers.

(2) Extreme sparseness of individual plants, the vegetation being thinly scattered.

(3) Monotony of the country and of the plant groups (one type or species of plant may occupy a vast area).

(4) Absence of characteristic systematic groups above the genus (there are no families or tribes that are most typical of the Sahara, but several species and genera are typical of the region).

(5) The presence of a large number of endemic species.

(6) Human economy based on the culture of the date palm.

Cryptogamic vegetation is relatively sparse in the Sahara and is represented by approximately 100 species of mushrooms, lichens, algae, liverworts, and mosses; they comprise approximately 12 to 18 percent of the floral composition. Bacteria and filamentous mushrooms have developed even in barren soils which contain no phanerogamic vegetation.

### Systematic Composition

The Gramineae, Leguminosae, and the Compositae are considered by Ozenda to represent the dominant families of the Sahara. Even though these three families represent about 35 to 40 percent of the floral composition of the Sahara, they are not the most typical Saharan families. The Chenopodiaceae with two endemic genera, *Fredolia* Coss. and Dur. and *Nucularia* Batt.; the Cruciferae represented by numerous genera and species; and the Zygophyllaceae including the genus *Fagonia* L., are the most typical families of plants in the Libyan flora. Representatives of the latter family are almost nonexistent in the Mediterranean littoral. The Cruciferae and Chenopodiaceae, however, have numerous representatives in the Mediterranean region and the entire Holarctic Floral Empire.

Generic dominance, with the number of species in each genus of the plants of the northern Sahara, including Libya (Fezzan), is as follows: *Astragalus* L., 8; *Fagonia* L., 8; *Aristida* L., 8; *Launaea* Cassini, 7; *Reseda* L., 6; *Salsola* L., 6; *Plantago* L., 6; *Tamarix* L., 5; *Euphorbia* L., 5. These genera belong to the families Gramineae, Leguminosae, Com-

positae, Zygophyllaceae, Resedaceae, Chenopodiaceae, Plantaginaceae, Tamaricaceae, and Euphorbiaceae.

Owing to the few species (one or two) representing each genus of the Cruciferae in the Sahara, this family is not included with the above account of generic dominance, which is based on only those genera containing five or more species. Because of the large number of Saharan genera comprising the Cruciferae, it is still regarded as one of the dominant families.

### Endemism

In the Libyan Sahara, the presence of vast spaces almost unfit for life constitute barriers to the dissemination of species, and endemism is particularly well developed. Some plants are endemic to particular geographic formations (mountains, sand seas, and hamadas). Other species have a wider range of endemism and are endemic to the entire Sahara; therefore, all degrees of endemism are possible.

Specific endemism attained in the Sahara is in the neighborhood of 25 percent of the total component plant species (162 endemic species of vascular plants out of a total of 650 species). Ozenda lists 35 species of endemic vascular plants in the northern Sahara, many of which occur in Libya.

### Adaptation to the Desert Environment

The problem of adaptation of plants to a desert climate involves primarily an adjustment to long dry periods. A large proportion of desert plants shorten their life cycle and thereby suppress their aerial parts during periods of drought. Others maintain their aerial parts but have an arrangement of anatomical devices which tend to diminish water loss by evaporation.

In the Sahara, two types of vegetation can be distinguished according to the length of their life cycles: temporary vegetation and permanent vegetation.

The temporary vegetation is divisible into annual plants and the geophytes. Following the rains, annual plants appear suddenly and develop with amazing rapidity, completing their life cycle, including flowering and fruiting, before the soil becomes dry. The length of the vegetative cycle is variable among the different species but generally is about four months. Some species of the genera *Boerhavia* L. and *Tribulus* L. complete their development from germination to the production of seeds in 8 to 15 days. Additional examples of Saharan ephemerophytes include *Convolvulus fatmensis* Kunze, *Launaea glomerata* (Cass.) Hook, *Schismus barbatus* (L.) Thell., and *Plantago albicans* L. These ephemeral plants are important as sources of food for domestic animals.

Geophytes are plants which are able to survive periods of drought by the development of enlarged subterranean organs such as bulbs and rhizomes. These are represented chiefly by members of the Umbelliferae.

Permanent vegetation has adapted to the aridity of the desert by the development of anatomical and morphological structures which increase the amount of water absorption and decrease evaporating surfaces. In general, a high level of absorption is insured by the maintenance of greater hypertonicity in the roots than in the aerial parts. The roots of these desert plants are frequently elongated and specialized to absorb water more efficiently in any given type of soil.

The problem of water retention in desert plants has been solved by a reduction in the evaporating or transpirating surfaces, a reduction in the speed of evaporation, and by the accumulation of water in the tissues. Species belonging to the family Chenopodiaceae and to the genera *Ephedra* L. and *Calligonum* L. have minute flowers and are even apetalous. In the case of *Anabasis articulata* Moq., *Tamarix gallica* L., and *Calligonum*, the leaves drop off during the dry season. In other plants (sclerophytes), the epidermis is covered with a thick cuticle formed of sclerified cells, which retard significantly the speed of evaporation or transpiration. Succulent plants which store water in the tissues are represented in the Sahara by relatively few species belonging to the genera *Mesembryanthemum* L., *Euphorbia*, and *Caralluma* R. Br.

In the northern Sahara, including the steppe and deserts of Libya, there are approximately 20 species of trees or arborescent plants. These include such well-known genera as *Ephedra, Cupressus* L., *Phoenix* L., *Ficus* L., *Acacia* Mill., *Pistacia* L., *Tamarix, Calotropis* R. Br., *Olea* L., *Calligonum*, *Rhus* L., and certain arborescent genera of the Chenopodiaceae.

### The Vegetative Cover of Libya

*Coastal Plain.* Floral composition and density of plants of the Libyan coastal plain varies considerably from region to region depending upon the character of the soil and upon the season. Generally, the vegetative cover of the coastal plain is denuded by overgrazing but occasionally it is quite dense and uniform. The most typical pattern consists of extensive areas of small hillocks supporting bushlike plants. Emergent grasses and annuals are sometimes interspersed among these hillocks. Zavattari (1934) states that the following genera are the most typical of the coastal plain: *Hyparrhenia* Anderss., *Imperata* Cyrill., *Agropyron* L., *Cyperus* L., *Pancratium* L., *Silene* L., *Euphorbia*, and *Ononis* L. In sandy areas of the coastal plain, the vegetative cover is sparser and consists of larger, bushlike species

such as *Calligonum*. The large coastal dunes also support a meager vegetative cover.

In those portions of the coastal plain where salt concentration is relatively high, halophytic species are dominant. Certain species such as *Crithmum maritimum* L., *Lotus argenteus* Webb, *Beta maritima* L., *Dactylis glomerata* L., and *Agropyron junceiforme* (A. and D. Löve), indicate transitional areas in the gradient of salt concentration of the soil. Considerable areas of salt marshes exist in Tripolitania near Zuara, Misurata, Tauorga, Agedabia, and in various other localities along the coastal plain of northern Cyrenaica adjacent to the Mediterranean Sea. These areas are characterized by typical halophytic genera, which include *Salicornia* L., *Suaeda* Forsk. *Arthrocnemum* Moq., *Halocnemum* Marsch.-Bieb., and *Salsola* L.

The coastal plain near Tocra in Cyrenaica consists of a broad bush-covered plain which differs markedly from the typical vegetative cover elsewhere on the coastal plain. In coastal Tripolitania, large wadis dissect the coastal plain and frequently are bordered by thorny, bushlike perennials, some of which occur on large hummocks.

Many areas of the coastal plain, particularly those of northwestern Tripolitania, have been modified by man and support extensive groves of olives and date palms and vineyards. Eucalyptus trees and bull-thorn acacia have also been planted along many of the roadsides. The vegetative cover of large portions of the Gefara plain of northwestern Tripolitania is not typical of that of the coastal plain and is covered instead with a shrub-steppe type of vegetation.

*Cyrenaican Plateau.* The lush and varied flora of the Cyrenaican Plateau is predominantly of Mediterranean affinities and consists of a variety of arborescent species, grasses, and other herbaceous plants. Most of the canyons and broad slopes of the plateau are covered with dense chaparral consisting of several genera of treelike forms. These genera include primarily *Quercus* L., *Viburnum* L., and *Juniperus* L. Some of the larger wadis, such as the Wadi el Kuf, support occasional stands of *Pinus* L. and *Cupressus* L. In the higher portions of the plateau, especially along the northern portions, a savanna type of vegetative cover is present, consisting of grassy plains with occasional juniper or cypress trees. In those areas where agriculture is widespread, the grass cover is interrupted by open fields and cultivated areas. Numerous other genera of plants occur on the plateau either as understory vegetation or as perennials associated with agricultural areas. Narrow strips of mesophytic vegetation border the few permanent streams which drain from the plateau, and small pockets of mesophytic plants occur near springs

and other sources of water. The genera most frequently found in these mesic habitats are: *Typha* L., *Potamogeton* L., *Phragmites* Trin., and *Cyperus* L.

*Tripolitanian Gebel.* The floral composition of the Tripolitanian Gebel (Gebel Nefusa) differs markedly from that of the Cyrenaican Plateau and has greater affinities with the flora of the Saharan steppe. The vegetative cover of the Tripolitanian Gebel is sparser and consists of a smaller assemblage of species. Grasses, chiefly *Stipa* L., constitute the dominant element in the plant cover. Other plants present on the Gebel, which are considered more typical of the Saharan steppe, include *Teucrium* L., *Lavandula* L., and *Rhamnus* L. Olive trees (*Olea*) occur in the less rugged areas of the Gebel, and date palms (*Phoenix dactylifera* L.) are of localized occurrence on the terraces of the coastal escarpment.

*Saharan steppe.* The Saharan steppe, or transitional desert of Libya, extends as a broad belt of scrub desert vegetation between the denser plant cover of the coastal plain and the extremely sparse vegetative cover of the Saharan interior. This semiarid region contains plant species typical of both the Mediterranean and Saharo-Sindien Floral Regions. In any given area of transitional desert, the vegetation tends to be rather uniform and frequently large areas are dominated by specific types. Several different types of steppes can thus be distinguished in Libya based upon the dominant plant occurring in each. Chief among these types of steppe are the *Asphodelus* L. steppe, the *Artemisia* L. steppe, and the *Aristida-Stipa* L. steppe. In the steppe region south of the Cyrenaican Plateau and near the Gulf of Sirte, the genera *Asphodelus* and *Lygeum* L. are common. The most widely spread plant genus of the Libyan steppe is *Aristida*. The vegetative cover of this semiarid region sometimes extends uninterruptedly for 200 kilometers or more but becomes more sporadic and localized near the northern margins of the Sahara proper. In this steppe region, acacia trees (usually *Acacia radianna* Savi) are not uncommon and occur either singly or as small groups along the margins of the larger wadis.

*Sand seas, hamadas, and serirs.* In the sand seas the grass, *Aristida pungens* Desf., is the dominant herbaceous plant. In areas where the sand has become stabilized, plant cover is characterized by the following arborescent genera: *Ephedra*, *Retama* Boiss., *Genista* DC., and *Calligonum*. *Cyperus* and *Moltkia* Lehm. are the most abundant herbaceous plants.

The sparse vegetative cover of the hamadas consists of several characteristic genera which include *Haloxylon* deBunge, *Fagonia*, and *Fredolia* Coss. and Dur. Following periods of rain, a variety of annual

plants develop and sometimes extend over large areas of the hamadas. These annuals are represented by *Erodium* L'Hérit, *Lifago* Schweinf. and Muschl., *Convolvulus* L., and *Urginea* Steinheil.

In the serirs, where the surface layer is sandy, grasses belonging to the genus *Aristida* constitute the major vegetative cover. The floral cover of these sandy plains is generally denser and more varied than that of the hamadas. The following genera are most common: *Androcymbium* Willd. and *Asphodelus*, representing forms with underground bulbs or tubers; *Daucus* L. and *Ammodaucus* Coss. and Dur., which are annuals; *Cornulaca* Del., a thorny chenopod; and *Randonia* Coss., a bushlike perennial. Wild gourds, *Colocynthis vulgaris* (L.) Schrad., occur in both hamadas and serirs.

*Depressions or sebchets.* The large saline depressions or sebchets in various parts of Libya have a distinctive flora consisting of salt-tolerant representatives of the Chenopodiaceae, such as *Salsola*, *Traganum* Del., *Atriplex* L., *Cornulaca*, and *Suaeda*. Other families are represented by *Zygophyllum* L. and *Frankenia* L.

Sixty-five species of herbaceous and woody plants are recorded from the vicinity of Giarabub Oasis, many of which belong to well-known salt-tolerant genera and are capable of existing under conditions of marked alkalinity. The most salt-tolerant of these include *Chenopodium* L., *Arthrocnemum*, and *Salsola*. In some of the larger sebchets, several successional stages are apparent in the flora extending from areas of high-salt concentrations to those of lower concentrations. Along the margins of the depressions where the soil is less saline, tamarix and date palms are sometimes abundant. Near the saline lake of Bahr el Tubat in eastern Cyrenaica, dense growths of *Phragmites* occur on the moist, sandy-clay soils near the margins of the zone of true halophytic plants.

*Oases.* Owing to their high water tables, the oases in the interior of Libya support a lush flora entirely unlike that of other areas. Large groves of date palms (*Phoenix dactylifera*) are the dominant vegetative feature of the oases, but numerous other plants of agricultural significance, such as figs, wheat, and alfalfa, are also present. On the periphery of the oases, and to a lesser extent in the interior, tamarix is relatively common. This outer zone of tamarix is typical of almost all larger oases in Libya. In these outlying areas tamarix forms clones of considerable size on sandy soils and occurs sparingly on top of large sandy-clay hummocks. Frequently, *Calligonum* occupies these same hummocks. The hummocks supporting *Tamarix* and *Calligonum* frequently occur for 20 kilometers or more beyond the palm groves of the oases.

In many large oases, such as Cufra, Tazerbo, and Bzema, small lakes (mostly saline) occupy the central portions and are bordered

by dense growths of sedges and other mesophytic plants. In those oases where the water table is near the surface, sedges (*Cyperus* and *Scirpus* L.) occur over an appreciable portion of the oasis. Besides sedges, the most abundant species of emergent vegetation are *Polypogon monspeliensis* (L.) Desf., *Erianthus ravennae* (L.) Beauv. *Imperata cylindrica* (L.) Beauv. *Phragmites communis* Trin., *Desmostachya bipinnata* (L.) Stapf., *Juncus bufonius* L., *Juncus maritimus* Lam., and *Typha angustifolia* L. At the oasis of Brach in the Fezzan, fresh water is abundant and supports dense growths of *Phragmites*.

In the broad, shallow wadis of the Fezzan, date palms and tamarix occur almost uninterruptedly for stretches of 50 kilometers or more and, in effect, have all of the floral characteristics of the isolated oases. The oases in the Wadi es Sciati, north of Sebha, and those of Murzuch, Traghen, Umm el Araneb, Meseguin, and Zuila are linked together by scattered palms and tamarix.

In the Wadi el Agial, southwest of Sebha, groves of date palms extend uninterruptedly for over 150 kilometers.

*The grass cover of Libya.* The grass cover of Libya has been divided by Rattray (1960) into six regions based on the dominant type of grasses present. The *Phalaris* L. type is associated with a woodland habitat and is limited to the uplands of the Cyrenaican Plateau. Several other species of grasses are also commonly associated in this *Phalaris* type of grass cover. These include *Hordeum bulbosum* L., *Poa bulbosa* L., *Lolium rigidum* Gaud., *Oryzopsis miliacea* (L.) Aschers. and Schweinf., and *Dactylis glomerata*.

Rattray includes the coastal fringes and littoral deserts of Libya within the *Hyparrhenia* type of grass cover. Because of intensive utilization in this region, the vegetation has been reduced to a shrub steppe, but in protected areas, *Hyparrhenia hirta* (L.) Stapf. is the dominant grass. The grasses *Oryzopsis miliacea* and *Cynodon dactylon* (L.) Pers. are also common in the *Hyparrhenia* zone which occurs at altitudes ranging from sea level to over 600 feet and receives from 8 to 16 inches of rainfall during the winter season.

According to Rattray, a small portion of the Gefara Plain of northwestern Tripolitania belongs to the *Stipa lagascae* Roem. and Schult.-*Stipa parviflora* Desf. type of grass cover. This is a sparsely growing perennial grass cover interspersed among a shrub-steppe type of vegetation consisting of *Ziziphus lotus* (L.) Desf., *Artemisia campestris* L., and *Rhanterium suaveolens* Desf. This type of grass cover occurs at elevations ranging from sea level to 650 feet and with a winter rainfall of 6 to 10 inches.

The *Stipa tenacissima* L.-*Lygeum spartum* Loefl. type of grass cover represents a perennial grassland on the Gebel Nefusa and adjoining portions of the Tripolitanian Gebel. This association usually occurs

285-134 O—68——3

with a discontinuous cover of small shrubs, primarily *Artemisia*. The large grass *Stipa tenacissima*, known locally as "esparto" grass, is harvested and exported on a fairly large scale in some parts of coastal Libya.

Grass cover of the *Aristida* type is dominant in all desert areas of Libya. The *Aristida plumosa* L.-*A. obtusa* Del.-*A. acutifolia* Trin. and Rupr.-*A. ciliata* Desf.-*A. pungens* Desf. "type" is typical of the pre-Saharan or transitional desert area of northern Tripolitania and Cyrenaica. These grasses are also associated with a steppe type of vegetation consisting of small, scattered groups of acacia and desert shrubs. *Stipa lagascae*, *S. capensis* Thunb., and *S. barbata* Desf. are present but are not common in this zone.

In the Libyan Sahara, where the annual rainfall is less than two inches, the *Aristida spp.-Panicum turgidum* Forsk.-*Lasiurus hirsutus* Boiss.-*Pennisetum divisum* (Gmel.) Henrard "type" of grass cover is most characteristic. In the Sahara, these grasses are associated with scattered acacias and shrubs including such genera as *Anabasis* L., *Haloxylon*, and *Cornulaca*. Frequently vast areas are devoid of vegetation, and only an ephemeral cover of grasses and herbs appears following a period of rainfall.

## Mammalian Faunal Areas

Libya has three primary faunal areas based on the distribution of the rodent fauna. These areas coincide roughly with the major physiographic, vegetative, and climatic features of the country. These faunal areas are divisible into regional provinces according to the kinds of rodents most typical of each. These areas (with the provinces in parentheses) are: Mediterranean (Coastal Plain, Cyrenaican Plateau); Saharan steppe (Transitional Desert, Tripolitanian Gebel); and Saharan Desert (Cyrenaican Desert, Fezzanese Desert).

Each faunal area is characterized by certain species (or subspecies) restricted to it or which occur only marginally in an adjacent faunal area. Members of a given subspecies are usually confined to the same province, but occasionally representatives of a widely ranging subspecies can occur in both provinces of a faunal area. Representatives of genetically plastic subspecies frequently occur in more than one faunal area, but these are exceptional cases.

Owing to the diverse topography of Libya, a greater number of mammalian faunal zones could be expected. The aridity of the Saharan interior apparently renders most areas unfit for life, and as a result, only the most adaptable species of rodents are able to survive. Because the Saharan portion of Libya comprises most of the land area and because of the widespread distribution of most of the desert species, the faunal areas are correspondingly large.

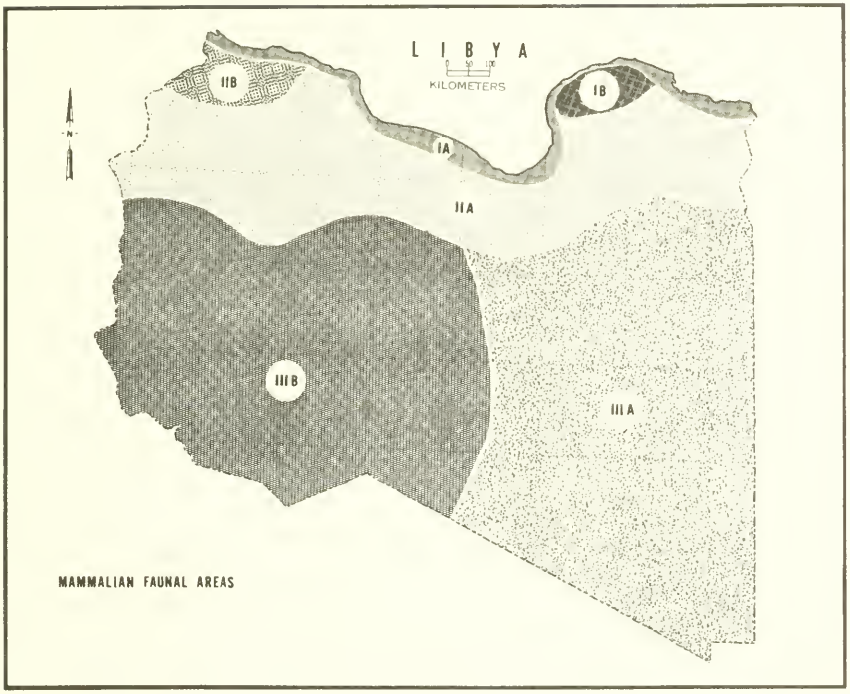


FIGURE 2.—I, Mediterranean Faunal Area; IA, Coastal Plain Province; IB, Cyrenaican Plateau Province; II, Saharan Steppe Faunal Area; IIA, Transitional Desert Province; IIB, Tripolitanian Gebel Province; III, Saharan Desert Faunal Area; IIIA, Cyrenaican Desert Province; IIIB, Fezzanese Desert Province.

Although the Mediterranean littoral and steppe regions of Libya cover a much smaller area than the Saharan portion, they are more varied, both climatically and physiographically. As a consequence, these northern portions of Libya support a more varied rodent fauna and are thus divisible into a greater number of faunal provinces.

Portions of these faunal provinces, and in some cases, the entire province, possess rodents which demonstrate a high degree of endemism; these areas act as centers of differentiation for several kinds of rodents. Genetic fixation among populations of Libyan rodents has arisen either through long periods of spatial (geographic) isolation or as a more local response to variations in the character of the climate, soil, and plant cover.

### Mediterranean Faunal Area

The Mediterranean Faunal Area comprises all the coastal areas of Libya, including the Cyrenaican Plateau. This faunal area is composed of the rather discrete Coastal Plain Province and the Cyrenaican

Plateau Province. The Coastal Plain Province includes the Mediterranean littoral from the seaward margins of the coastal plain to the coastal escarpment and northernmost edge of the hamadas of the Saharan steppe. The Cyrenaican Plateau comprises the massif of the Cyrenaican Plateau including the Gebel el Achdar.

Owing to the mild climate of these coastal areas and the greater amounts of rainfall and higher humidity, vegetative cover is denser and more varied than in other parts of Libya. This is particularly true of the Cyrenaican Plateau, which receives more rainfall than any other region of Libya and has a flora differing strikingly from that of the surrounding lowlands.

The ecologic and climatic distinctness of the Mediterranean Faunal Area is reflected in the greater number of kinds of rodents that occur there. Of the 56 kinds of rodents that occur in Libya, 31 are found in the Mediterranean Faunal Area—55 percent of the total Libyan rodent fauna.

The following species of rodents are restricted to the Mediterranean Faunal Area: *Microtus mustersi; Gerbillus eatoni; Gerbillus henleyi; Meriones libycus; Psammomys obesus; Spalax ehrenbergi;* and *Allactaga tetradactyla.*

The species *Rattus rattus* and *Rattus norvegicus* are also restricted to the coastal areas of Libya, but because of their commensal nature and tendency to be disseminated by man, they are not included in the above list. Because of its doubtful validity, *Gerbillus grobbeni*, which was described from specimens collected near Derna, has not been included.

Local differentiation of rodent populations in the Mediterranean Faunal Area has resulted in the formation of 16 subspecies representing 11 species. The majority of these subspecies (12) are restricted to the Coastal Plain Province and include *Gerbillus aureus favillus; Gerbillus eatoni eatoni; Gerbillus eatoni inflatus; Gerbillus eatoni versicolor; Gerbillus campestris wassifi; Gerbillus henleyi henleyi; Meriones caudatus confalonierii; Meriones libycus auratus; Meriones libycus azizi; Psammomys obesus obesus; Psammomys obesus tripolitanus;* and *Jaculus deserti favillus.*

The vole, *Microtus mustersi*, and the following subspecies occur in both the Cyrenaican Plateau Province and the Coastal Plain Province: *Gerbillus campestris brunnescens; Spalax ehrenbergi aegyptiacus; Eliomys quercinus cyrenaicus;* and *Jaculus orientalis orientalis.* With the exception of *Jaculus orientalis orientalis*, all are more abundant in the Cyrenaican Plateau Province. The subspecies *Gerbillus campestris brunnescens* and *Spalax ehrenbergi aegyptiacus* are the most typical rodents of the Cyrenaican Plateau and are common in almost all types of habitat and at all elevations.

The Cyrenaican Plateau, in view of its unique ecologic and climatic regimen, has a surprisingly depauperate rodent fauna. The absence of endemic subspecies in an area so distinct ecologically is most surprising. The most logical explanation for this lack of differentiation in the populations of rodents occurring here may be the close proximity of the coastal plain and, in many places, the continuity of similar habitats between it and the uplands of the plateau, which have allowed for genetic interchange between populations of rodents occurring in both areas.

The Coastal Plain Province has a richer rodent fauna than the Cyrenaican Plateau probably because of its larger area and its greater diversity of habitats. Although rainfall is more seasonal on the coastal plain, falling mostly during a comparatively short winter period, there are much greater local fluctuations in daily and yearly temperatures. Most inland areas of the coastal plain are contiguous with the Saharan steppe and tend to be somewhat arid. Some portions of the coastal plain, in floral composition and climate, do not differ appreciably from the Saharan steppe. This ecologic and climatic diversity has increased significantly the number of habitats available to mammals, and the rodent fauna is accordingly more diversified.

The most characteristic species of rodents of the Coastal Plain Province are: *Gerbillus eatoni; Gerbillus henleyi; Meriones libycus; Psammomys obesus; Jaculus orientalis;* and *Allactaga tetradactyla.* All of these species except *Jaculus orientalis,* which occurs on the Cyrenaican Plateau and Gebel Nefusa, are restricted to the coastal plain. Most of these coastal species have developed subspecies in response to local differences in the character of the coastal plain. Thus *Gerbillus eatoni* is divisible into three subspecies, *G. e. eatoni,* with a broad range covering the southern margins of the Gulf of Sirte; *G. e. inflatus,* which is confined to the coastal plain of extreme northeastern Cyrenaica; and *G. e. versicolor,* whose range includes the coastal plain of the eastern margins of the Gulf of Sirte.

The sand rat, *Psammomys obesus,* is represented by two subspecies, *P. o. obesus* and *P. o. tripolitanus,* which are confined, respectively, to the coastal plains of northeastern Cyrenaica and the Gulf of Sirte.

*Meriones libycus* is also divisible into two coastal subspecies. The range of *Meriones libycus auratus* includes all coastal areas of Tripolitania and those areas adjoining the southern margins of the Gulf of Sirte, while *Meriones libycus azizi* is confined to the coastal plain of northern Cyrenaica.

The species *Gerbillus henleyi* and *Jaculus orientalis* inhabit large portions of the Libyan coastal plain but have not differentiated sufficiently in Libya to warrant division into subspecies. The monotypic species, *Allactaga tetradactyla,* likewise has not formed subspecies.

In Libya, this species is known only from a few specimens from El Agheila and Gheminez on the Cyrenaican coastal plain; therefore, its taxonomic status is not well established.

Subspecies confined to the Libyan coastal areas representing populations on the periphery of the ranges of their respective species are: *Gerbillus campestris wassifi; Meriones caudatus confalonierii; Eliomys quercinus cyrenaicus;* and *Jaculus deserti favillus.*

Because of the encroachment of the Saharan steppe onto portions of the coastal plain, some subspecies, which typically inhabit the Saharan Steppe Faunal Area, occur marginally in the Coastal Plain Province. Chief among these intrusions from the steppe regions are representatives of the following subspecies: *Gerbillus campestris dodsoni; Gerbillus gerbillus psammophilous; Gerbillus pyramidum hamadensis; Pachyuromys duprasi natronensis; Meriones caudatus luridus;* and *Jaculus jaculus whitchurchi.*

Conversely, members of typical coastal subspecies penetrate short distances into the Saharan Steppe Faunal Area. Examples of coastal subspecies which are found occasionally along the northern margins of the steppe region are: *Gerbillus eatoni eatoni; Gerbillus henleyi henleyi; Meriones libycus auratus; Spalax ehrenbergi aegyptiacus;* and *Jaculus deserti favillus.*

From the above examples, it is apparent that elements of two different faunal areas overlap in some parts of coastal Libya.

Distributions of the porcupine (*Hystrix cristata*), the large Egyptian jerboa (*Jaculus orientalis*), and the small gerbil (*Gerbillus kaiseri*) do not conform to other distributional patterns of rodents in Libya. All three are known from both the Cyrenaican Plateau and the Gebel Nefusa, which belong, respectively, to provinces of the Mediterranean and Saharan Steppe Faunal Areas. Such a discontinuous distribution for members of the same species strongly opposes modern concepts of speciation. It is most likely, therefore, that the populations of *J. orientalis* and *G. kaiseri* on the Gebel Nefusa are relicts of formerly continuous populations. The porcupine, owing to its reputed adaptability and tenacity, represents a genetically plastic species which has been affected less by ecologic and climatic barriers and thus has not followed the distributional patterns of other Libyan rodents.

### Saharan Steppe Faunal Area

The Saharan Steppe Faunal Area comprises the steppe region of Libya located between the inner margins of the coastal plain and the Saharan interior; it is situated between the Mediterranean Faunal Area and the Saharan Faunal Area. The Saharan Steppe Faunal Area is divisible into two distributional provinces, the Transitional Desert Province and the Tripolitanian Gebel Province. The Transitional

Desert Province includes the Saharan steppe and is the larger province of the two. The Tripolitanian Gebel Province consists of the Gebel Nefusa, Gebel Tigrinna, and the mountainous coastal escarpment of northwestern Tripolitania. Because the rodents of the Gefara Plain resemble those of the nearby gebel areas, this portion of the Tripolitanian coastal plain is included in the Tripolitanian Gebel Province.

Twenty-four kinds of rodents occur in the Saharan Steppe Faunal Area, representing 17 species and 19 subspecies. In contrast to the rather large number of species restricted to the Mediterranean Faunal Area, the Saharan Steppe Faunal Area has only *Psammomys vexillaris* and *Ctenodactylus gundi* restricted to it. Besides these two, other species of rodents occurring in this faunal area are: *Gerbillus amoenus; Gerbillus aureus; Gerbillus campestris; Gerbillus gerbillus; Gerbillus kaiseri, Gerbillus pyramidum, Pachyuromys duprasi; Meriones caudatus; Meriones crassus; Mus musculus; Acomys cahirinus; Eliomys quercinus; Jaculus deserti; Jaculus jaculus;* and *Hystrix cristata.* Of the above species, *Gerbillus aureus, Pachyuromys duprasi, Meriones caudatus, Jaculus deserti,* and *Ctenodactylus gundi* are most characteristic of the Saharan Steppe Faunal Area. *Gerbillus campestris, Gerbillus gerbillus,* and *Jaculus jaculus* are relatively common but are more abundant farther south in the Saharan Faunal Area.

The Tripolitanian Gebel Province is distinctive in having restricted to it: *Gerbillus aureus aureus; Gerbillus aureus nalutensis; Eliomys quercinus tunetae; Jaculus jaculus tripolitanicus;* and *Ctenodactylus gundi gundi.*

The following subspecies are either confined to the Transitional Desert Province in Libya or occur only marginally in neighboring faunal areas: *Gerbillus campestris haymani; Gerbillus gerbillus gerbillus; Gerbillus gerbillus latastei; Gerbillus pyramidum hamadensis; Meriones caudatus caudatus; Meriones caudatus luridus; Psammomys vexillaris vexillaris; Jaculus jaculus whitchurchi;* and *Ctenodactylus gundi vali.*

Giarabub is the northernmost of the Saharan oases and has floral and edaphic elements resembling those of the more southern oases of Cyrenaica. For this reason and because of its geographic position on the northern portion of the Libyan Desert, Giarabub Oasis would be expected to have a rodent fauna related to that of the Saharan Faunal Area to the south. Instead, rodents from this oasis are related more closely to the rodent fauna of the Saharan Steppe Faunal Area to the north. Apparently the Sand Sea of Calanscio and the Serir of Calanscio have served to isolate rodent populations of Giarabub Oasis from those to the south. To the north, suitable habitat, although localized, is sufficiently widespread to allow for the dispersal of rodents.

The subspecies *Gerbillus gerbillus gerbillus* and *Gerbillus campestris haymani* apparently reach their westernmost distributional limits at

Giarabub. Representatives of both also occur farther east at Siwa Oasis in the Western Desert of Egypt. In northern Egypt, the great chain of depressions composed of the Wadi Natroun, Qattara Depression, and Siwa Oasis probably has acted as a dispersal corridor through which members of these two subspecies have extended their range into Libya.

### Saharan Desert Faunal Area

The Saharan Desert Faunal Area comprises all of Libya south of the Saharan Steppe Faunal Area. This faunal area is limited entirely to the truly Saharan portions of Libya and is divisible into an eastern Cyrenaican Desert Province and a western Fezzanese Desert Province.

Owing to the insular distribution and relative isolation of populations of rodents in the Saharan Desert Faunal Area, a high degree of endemism is found. Although no full species are restricted to this faunal area, 11 of the 16 subspecies which occur here are endemic. This high proportion of endemic subspecies is a most distinctive feature of this area.

The most widespread species of rodents in this faunal area include *Gerbillus gerbillus, Gerbillus campestris,* and *Jaculus jaculus.* These are all typical desert species and are common also in the steppe and littoral desert regions of Libya.

The Fezzanese Desert Province is confined in Libya to the Fezzan but includes adjacent portions of southeastern Algeria and parts of northern Niger and the Chad. This province is bordered on the north and east by the mountainous barriers of the Hamada de Tinrhert and the volcanic massifs of the Gebel es Soda and the Gebel el Harug el Asued. It is limited on the west by the mountain complex of Tassil-n-Ajjer and the Ahaggar Mountains of southeastern Algeria and on the south by the Plateau de Mangueni of northern Niger and the Tibesti Mountains of northern Chad. All these surrounding, rocky mountainous areas provide unsuitable habitat for most species of rodents occurring in the Fezzan. Genetic exchange with populations outside of the Fezzan, therefore, has been of rare occurrence and a large number of endemic subspecies have arisen. Endemic rodents in the Fezzanese Desert Province are: *Gerbillus gerbillus discolor; Gerbillus pyramidum tarabuli; Meriones caudatus amplus; Eliomys quercinus denticulatus;* and *Jaculus jaculus arenaceous.*

The Cyrenaican Desert Province is limited to the central and southern portions of Cyrenaica and includes the desolate areas of the Sand Sea and Serir of Calanscio and the isolated oases of southern Cyrenaica. This province is characterized also by a largely endemic fauna and has restricted to it: *Gerbillus gerbillus aeruginosus; Gerbillus campestris patrizii; Jaculus deserti rarus; Jaculus deserti vastus; Jaculus jaculus collinsi;* and *Jaculus jaculus cufrensis.*

Several subspecies of genetically plastic species are distributed over wide geographic areas in Libya and do not conform to faunal areas and provinces. These Libyan subspecies, which occur in more than one faunal area, are: *Gerbillus amoenus vivax; Gerbillus campestris dodsoni; Gerbillus gerbillus psammophilous; Meriones crassus tripolius,* and *Acomys cahirinus viator.*

*Gerbillus campestris dodsoni* occupies the largest range of any subspecies of Libyan rodent and is found in all four provinces of the Saharan and Saharan Steppe Faunal Areas. In the Fezzan and southern Cyrenaica, this subspecies is largely confined to the oases where it is usually concentrated in the more mesic portions. In the Tripolitanian steppe and the Gebel Nefusa, it is almost always confined to rocky habitats. Less commonly, members of this subspecies occur in sandy habitats. By virtue of this apparent wide ecological tolerance, G. *c. dodsoni* is able to occupy this large geographic area.

The species *Gerbillus amoenus* and *Meriones crassus* require similar habitats and have almost identical ranges in Libya, including the Libyan Fezzan and portions of the Tripolitanian steppe. Each is represented in Libya by a single subspecies.

The range of *Gerbillus gerbillus psammophilous* includes a vast area in Cyrenaica extending from the interior oases of Tazerbo and Bir el Harasc to the margins of the coastal plain. Representatives of this subspecies occur near Agedabia on the inner margins of the Cyrenaican coastal plain, at Gasr es Sahabi in the Cyrenaican steppe, and at Gialo, which is one of the northernmost of the Libyan Saharan oases. The range of this subspecies includes portions of all three major Libyan faunal areas.

In Libya, the spiny mouse, *Acomys cahirinus viator,* is known from three widely separated localities which include El Giof of Cufra Oasis in southern Cyrenaica, the oases of Socna and Bir Fergian of southeastern Tripolitania, and the oasis of El Barcat in the Fezzan. It is doubtful that populations of these mice having such a strikingly discontinuous distribution (polytopic) actually belong to the same subspecies. Until larger series become available from more localities in Libya and permit a more accurate analysis of the morphological characters of these spiny mice, their taxonomic status should be considered provisional.

The house mouse, *Mus musculus,* is the most widespread of Libyan rodents and is the only species which occurs in all faunal areas and provinces. These mice occur as commensals in many coastal cities and, by the agency of man, have colonized almost all of the isolated oases of Cyrenaica and the Fezzan. They occur also as wild or feral populations in almost every type of habitat. On the coastal plain and the Cyrenaican Plateau, where the vegetative cover is relatively uniform and dense, house mice are practically ubiquitous. In the more arid

Saharan steppe and Sahara Desert, they are more localized and usually confined to the more mesic areas of the larger oases. Occasionally, house mice are obtained, along with jerboas, gerbils, and jirds, from the sandy periphery of the oases, but these habitats are probably suboptimal.

## Speciation and Geographical Variation

Most of the species of Libyan rodents satisfy the requirements of the multidimensional, polytypic species being composed of groups of local populations that "actually or potentially" interbreed with each other. In some genetically plastic species, such as *Jaculus jaculus* and *Gerbillus gerbillus*, there are varying degrees of gene flow among the various local populations resulting in pronounced phenotypic variability. Other species, which are more restricted ecologically, such as *Gerbillus pyramidum*, *Eliomys quercinus*, and *Meriones caudatus*, are composed of discontinuous allopatric populations, many of which are geographic isolates and thus only potentially capable of interbreeding. Members of each species of Libyan rodents share in a common gene pool and do not outbreed with members of other contiguous or sympatric species. By virtue of these two biological characteristics they conform to modern concepts of "biological species."

The species *Gerbillus gerbillus* and *Jaculus jaculus* serve to illustrate the concept of polytypic species. Each has a wide distribution in Libya and has developed several subspecies in response to selective pressures of the local environment. The pattern of distribution of the subspecies of *Jaculus jaculus* and *Gerbillus gerbillus* is essentially continuous, the range of one subspecies overlapping with that of the contiguous subspecies. In some cases, zones of intergradation are demonstrable.

In Libya, several species of rodents show varying degrees of morphological differentiation, and in some cases, certain populations have progressed to the level of subspecific distinctness. Libyan species which best demonstrate this geographic variation and the number of subspecies comprising each are: *Ctenodactylus gundi*, 2; *Eliomys quercinus*, 3; *Gerbillus aureus* 3; *Gerbillus campestris* 5; *Gerbillus eatoni* 3; *Gerbillus gerbillus* 5; *Gerbillus pyramidum* 2; *Jaculus deserti* 4; *Jaculus jaculus* 5; *Meriones caudatus* 4; *Meriones libycus* 2; and *Psammomys obesus* 2.

All of the above species are polytypic and are represented by at least two subspecies. Some species of Libyan rodents, however, are remarkably uniform, morphologically, over extensive areas of Libya and, as a consequence, are not divisible into subspecies. Species of rodents which are either monotypic or represented in Libya by a single subspecies are: *Gerbillus amoenus; Gerbillus henleyi; Gerbillus kaiseri; Jaculus orientalis; Allactaga tetradactyla; Microtus mustersi;*

*Pachuromys duprasi; Acomys cahirinus; Hystrix cristata;* and *Psammomys vexillaris.*

Most of the above species are more highly specialized than the polytypic species discussed earlier; consequently, they are less variable genetically and show a more limited range of phenotypic expression. In such genetically impoverished species, natural selection has fewer opportunities to alter genotypic and phenotypic composition of the population, and morphological characteristics of these species tend to remain relatively uniform, sometimes over large areas. Usually the geographic ranges of these genetically static species tend to be small because of the narrow ecological tolerance of the individuals comprising the population. This tendency for more specialized forms to have smaller geographic ranges is exemplified by *Spalax ehrenbergi Gerbillus kaiseri, Gerbillus eatoni,* and *Gerbillus henleyi,* all of which have ranges confined to northern Cyrenaica or areas near the Libyan coast. On the other hand, species such as *Gerbillus gerbillus, Gerbillus campestris,* and *Jaculus jaculus,* which have broad genetic constitutions, occur virtually throughout Libya.

### Geographic Variation in Response to Selective Factors of the Habitat

Morphological variation in rodent populations in Libya usually does not conform to climatic or ecogeographical rules, such as Bergmann's Rule and Allen's Rule. In some species, trends in morphological gradients are directly opposite those predicted by the rules. These ecogeographical rules actually have a broad application and are normally apparent only in faunas spanning entire continents. Conformation, therefore, cannot really be expected on such a small scale. In Libya, those species that do conform probably do so by coincidence.

Geographic variation in response to selective factors of the habitat is most apparent in the cryptic coloration of rodents living on different types of substrate. Coloration of many subspecies and populations of Libyan rodents closely corresponds to the color of the substrate on and in which they live.

The subspecies of *Gerbillus campestris* and *Meriones caudatus* demonstrate this substrate adaptation very well. On the Cyrenaican Plateau, representatives of *Gerbillus campestris brunnescens* are all of a dark chestnut dorsal color, reflecting the dark color of the substrate. Farther south and west in the desert areas of Libya, gerbils representing *Gerbillus campestris dodsoni* are markedly paler in dorsal color in response to the pale color of the sand and desert soils. The dorsal color of *G. c. dodsoni* is quite varied and several distinct color patterns are sometimes present within the same local population. This polymorphism in dorsal color is discussed in greater detail below.

A similar adaptation to color of the substrate is shown by subspecies of *Meriones caudatus*. In the Fezzan, the pale and uniform dorsal color of jirds referrable to *Meriones caudatus amplus* may reflect the prevailing pale coloration of the desert substrate. To the north, populations of *Meriones caudatus caudatus* and *M. c. confalonierii* which inhabit the darker, more grayish soils of the steppe and coastal plain are correspondingly darker in color with a stronger suffusion of black on the dorsum.

Cryptically colored individuals in a population of rodents where predation is widespread probably have a selective advantage over those less cryptically colored. In most cases a predator, whether it be an owl, fox, or jackal, would most likely select individuals that were most discordant with the color of their surroundings.

To determine whether or not these "substrate races" are the result of predator selection would require much more detailed research, but it is the most plausible explanation at present.

The adaptive significance of this cryptic coloration in Libyan rodents may be related to climatic factors, such as humidity, aridity, and solar radiation or may reflect relative density or sparseness of vegetative cover.

The subspecies *Gerbillus campestris dodsoni* shows a high degree of polymorphism in dorsal color throughout its wide range in Libya. In the same local population, individuals range in color from uniformly tan or buff to almost dark brown and demonstrate varying degrees of streaked or variegated patches in the pelage. Members of this subspecies are highly polymorphic in dorsal color in some areas (Tazerbo and Brach Oases) and almost uniform in others (Gebel es Soda).

This type of color polymorphism in *Gerbillus campestris dodsoni* may be the result of "balanced polymorphism" resulting from a balance among the genotypes AA, Aa, and aa. This balance is subject to geographic variation, but polymorphism is insured by the selective superiority of heterozygotes over homozygotes.

Several subspecies of *Gerbillus gerbillus* all possess orangish dorsal color, which doubtless has a broad adaptive significance in the sandy areas in which these gerbils live. Constant genetic interchange among widely distributed local populations of these gerbils, however, has prevented the formation of distinct discontinuous "substrate races" as in *Gerbillus campestris* and *Meriones caudatus*.

### Modes of Speciation

Gradual speciation, as opposed to instantaneous speciation or macroevolution, has doubtless been the prevailing mode of speciation among Libyan rodents. Of the two types of gradual speciation, geographic speciation has played the primary role in the evolutionary

history of the Libyan rodent fauna. Sympatric speciation, or speciation without geographic separation, may be operative in Libyan rodents, but evidence to support geographic speciation is far greater.

*Sympatric speciation.* The presence in Libya of closely related sympatric species, differing more in ecological or biological characteristics than in morphological characters, is suggestive of a type of sympatric speciation. The following pairs of closely related species of Libyan rodents have greater ecological than morphological differences and, in this respect, resemble sibling species:

*Gerbillus eatoni* and *Gerbillus gerbillus*
*Jaculus deserti* and *Jaculus jaculus*

The above pairs are sympatric over portions of their range in Libya yet do not interbreed. Isolating mechanisms, which segregate each member of the species pair, involve habitat selection and behavioral characteristics which usually have a genetic basis and are not to be construed with geographic isolation, a topic that will be discussed later.

Habitat isolation contributes significantly to spatial segregation of these species of Libyan rodents; in the present study, examples will be limited to this type of isolating mechanism.

In many areas of coastal Tripolitania and Cyrenaica, *Gerbillus eatoni* and *Gerbillus gerbillus* occur together without loss of genetic identity. In these coastal habitats, *G. gerbillus* is almost exclusively confined to localized sandy areas of the coastal plain or to the barren margins of the nearby hamada, and *G. eatoni* seems to prefer the hard clay substrate of the coastal plain. Vegetative cover of the sandy areas and hamadas is generally extremely sparse, whereas that of the majority of the coastal plain is relatively dense. This habitat segregation is largely instrumental in the prevention of introgression of the gene pools of the respective species. In the absence of this habitat exclusion, *G. eatoni*, owing to its more static gene pool, would doubtless be "swamped out" by the more widely ranging and more adaptable *G. gerbillus*.

The dipodils, *Gerbillus amoenus* and *Gerbillus campestris*, also illustrate the principle of habitat isolation very well. These two species are sympatric throughout most of Libya and show no evidences of hybridization. *Gerbillus campestris* is highly polymorphic, both cranially and in dorsal color, whereas *G. amoenus* is remarkably uniform morphologically. The latter species is normally confined to sandy margins of the oases or to gravel plains of the steppes. The larger *G. campestris* shows a wide ecological tolerance and occupies a wide variety of habitats, including the sparsely vegetated gravel plains of the steppes, the margins of sand seas, the sandy environs of the oases, the dense chapparal vegetation of the Cyrenaican Plateau, and adjacent densely vegetated coastal plain. The preferred habitat of

*G. campestris*, however, seems to be the fissures and recesses of rocky outcroppings. Because of this broad range of ecological tolerance, *G. campestris* is the most widespread rodent in Libya. In this respect it parallels rather closely the ecological and genetic plasticity of the deer mouse, *Peromyscus maniculatus* (Wagner), of North America.

When *G. amoenus* and *G. campestris* inhabit the same oasis, the latter is almost invariably found to occupy the interior, more lush portions of the oasis, and *G. amoenus* is usually confined to the drier, peripheral zones. Thus, habitat exclusion is clearly operative.

Habitat exclusion is further demonstrated by these two species along the coastal escarpment where *G. campestris* is confined to rocky outcroppings or rock-strewn uplands, and *G. amoenus* invariably occupies the intervening pockets of sand and gravel.

Two sibling species of jerboas, *Jaculus deserti* and *Jaculus jaculus*, are sympatric over large parts of the Libyan interior but show subtle habitat preferences. *Jaculus deserti* occurs in the outlying hamadas and sparsely vegetated margins of wadis, whereas *J. jaculus* is confined more to margins of sand seas and dune areas associated with oases. Only rarely were both species found to occur in the same local area, and then the two species were never collected from the same portion of the trapline.

Sympatry of species of Libyan rodents is not limited to these few examples. In many areas of Libya, several species of genetically and morphologically distinct rodents occur in the same geographic area and demonstrate marked habitat exclusion.

In some oases, *Gerbillus gerbillus*, *Gerbillus pyramidum*, *Gerbillus campestris*, *Gerbillus amoenus*, *Meriones caudatus*, *Jaculus jaculus*, and *Mus musculus* are all present. In these oases, each species or species pair tends to inhabit a particular niche with consequent exclusion of the other species. The dense growth of sedges and other mesophytic plants of the interior of these oases are occupied exclusively by *Gerbillus campestris* and *Mus musculus*. In open sandy areas and around bases of palm trees, *Gerbillus gerbillus* and *Gerbillus pyramidum* are more abundant. *Meriones caudatus* is confined to sandy hummocks supporting shrubby young palms, and *Jaculus jaculus* and *Gerbillus amoenus* are confined largely to peripheral areas of oases in the zone of tamarix and outlying dunes.

Many additional factors probably prevent genetic exchange between closely related sympatric species of Libyan rodents. Some of these additional isolating mechanisms include behavioral barriers to mating, differences in the time of the breeding season, and mechanical incompatabilities, such as differences in the size and shape of the external genitalia.

*Geographic speciation.* In Libyan rodents, far more evidence is available to support speciation caused by geographic isolation. Because evolution is operative at the level of the local population, it is the degree of isolation of these local populations and the resulting cessation of gene flow between them that is of greatest significance in interpreting evolutionary progress. In some of the examples of geographic speciation discussed below, the subspecies themselves act as incipient species, but it is the geographic isolate which is the main focus of geographic speciation. In many instances geographic variation is clinal.

*Clinal variation.* Among Libyan rodents, the species *Gerbillus gerbillus*, *Meriones caudatus*, and *Gerbillus amoenus* demonstrate clinal variation. All of these species show progressive increase or decrease in the size of either external or cranial features. Other morphological and physiological characters of these three species doubtless undergo clinal changes, but detection of these characters requires extremely refined techniques, and, in some cases, living specimens would be required.

In eastern Cyrenaica, populations comprising the subspecies *Gerbillus gerbillus gerbillus*, *Gerbillus gerbillus psammophilous*, and *Gerbillus gerbillus aeruginosus* demonstrate a regular north to south progression in diminution of cranial and body size. Individuals of the largest body and cranial size are found in representatives of *G. g. gerbillus* in Giarabub Oasis near the northernmost limits of the range of this species in Libya. The trend of decreasing body and cranial size continues in a progressive fashion from north to south in populations of these gerbils from Gialo, Gasr es Sahabi, and Tazerbo. The extreme in small body and cranial size is shown by members of *G. g. aeruginosus* from Cufra and Bzema Oases of southeastern Cyrenaica.

A progressive increase in body and cranial size is clearly noticeable among populations of jirds extending southward from the coastal areas of Tripolitania to the interior of the Fezzan. Because of the relatively few localities from which specimens were examined, this character gradient lacks the uniformity of the cline in populations of *Gerbillus gerbillus*. The differences in external and cranial dimensions between representatives of *Meriones caudatus confalonierii* from coastal Tripolitania and members of *M. c. amplus* from the Fezzan are of the degree of specific distinctness. Populations of the two extremes of this character gradient have thus diverged much more than those of the cline in *Gerbillus gerbillus*. Apparently the more diverse physiography and more varied edaphic conditions of western Libya have proven to be a more severe deterrent to gene flow than has the more uniform terrain of eastern Cyrenaica.

The degree of smoothness of a cline gives some indication of the amount and regularity of gene flow between successively contiguous populations. Because environmental factors vary from region to region, phenotypic responses to the selective pressures of these environments also vary. Genetic exchange between neighboring populations, however, tends to smooth out phenotypic characters that result from this selection, and clinal patterns tend to be gradual and uniform.

In Libya, clinal patterns of geographic variation generally run from north to south or vice versa. The dipodil, *Gerbillus amoenus*, is an exception in having a pattern of clinal variation extending generally from east-northeast to west-southwest. This east-northeast west-southwest cline, showing progressively increasing cranial size, is demonstrable among populations of *G. amoenus* extending from the Nile Delta to eastern Algeria. Members of this species from northern Egypt and northern Cyrenaica have small, gracile skulls. In the Fezzan, representatives of *G. amoenus* have markedly larger and more robust skulls, while specimens examined from eastern Algeria are even larger cranially than any of those from Libya.

In all examples of clinal variation in Libyan rodents, only the broad features of clinal progression are observable, and these clinal gradients may be far more irregular than indicated. Regardless of local differences in clinal pattern, clines in Libyan rodents serve to demonstrate general trends in morphological variation. In many cases, a clinal population represents a stage in speciation, the morphological differences among populations being attributable to differences in their genetic constitution.

*Geographic isolates.* Subspecies of Libyan rodents representing geographic isolates have developed rather striking phenotypic characteristics as a result of their altered genetic constitutions. These subspecies are: *Gerbillus gerbillus aeruginosus; Gerbillus pyramidum hamadensis; Gerbillus campestris patrizii; Meriones caudatus amplus; Psammomys obesus tripolitanus; Psammomys vexillaris vexillaris; Eliomys quercinus cyrenaicus; Eliomys quercinus denticulatus; Jaculus deserti vastus; Jaculus jaculus cufrensis; Ctenodactylus gundi gundi; and Ctenodactylus gundi vali.*

Ranges of most of the above subspecies are located on the periphery of the range of their respective species. Many of these peripheral isolates have undergone marked morphological differentiation and are well on the way toward becoming full species. It is probable that in Libya most new species have arisen as a result of the genetic divergence of peripheral isolates.

The range of *Gerbillus pyramidum hamadensis* is limited to the coastal plain of the Gulf of Sirte and littoral deserts and steppes of northern Tripolitania. The nearest populations of gerbils belonging to this species are those of *G. p. tarabuli*, 200 kilometers farther south in the

Fezzan. This population of *G. p. hamadensis* represents the northernmost occurrence of the species *Gerbillus pyramidum* in Libya and as is sometimes typical of populations on the margins of a species range, it is sporadic and localized in occurrence. This subspecies has diverged strikingly morphologically from the nearest related populations in the Fezzan and is approaching full species status. There is no evidence of intergradation between *G. p. hamadensis* and *G. p. tarabuli* to the south. Apparently the mountainous areas of the Gebel es Soda and Gebel el Harug el Asued and the vast plateau of the Hamada el Hamra, which are located between the ranges of these two subspecies, act as absolute barriers to dispersal.

The distinct *Meriones caudatus amplus* of the Fezzan is another typical peripheral isolate which is near to achieving species distinctness. In the case of *M. c. amplus*, parental populations are to the north and east, rather than to the south as in *Gerbillus pyramidum hamadensis*.

The species *Psammomys obesus* is distributed along the coastal areas of the eastern Mediterranean, northern Egypt, and portions of coastal Libya. The subspecies *Psammomys obesus tripolitanus* of the coastal plain and littoral deserts along the Gulf of Sirte in Cyrenaica, Libya, represents the westernmost populations of the species *Psammomys obesus* in North Africa. The Cyrenaican Plateau is interposed between the range of *P. o. tripolitanus* and Egyptian populations representing the nominate subspecies. The amount of morphological divergence in populations of *P. o. tripolitanus* is far less than that demonstrated by *Gerbillus pyramidum hamadensis* or *Meriones caudatus amplus*. The Cyrenaican Plateau has acted more as a filter in retarding gene flow between populations of *Psammomys obesus* than as an absolute barrier.

It is possible that *Psammomys vexillaris vexillaris* represents a species evolved through the agency of geographic isolation. Although *Psammomys vexillaris* somewhat superficially resembles *Psammomys obesus*, it is clearly a separate species and is readily separable from *P. obesus* by its markedly smaller cranial size and external dimensions. Some time in the past, peripheral populations of the coastal species, *P. obesus*, may have become separated from the parental population. In time, this isolated population developed different morphological and ecological characteristics as a reflection of its altered genetic constitution. The continuous action of selection has resulted in the evolution of additional isolating mechanisms, both ecological and behavioral, and this inland population of sand rats is now both spatially and reproductively isolated from the parental population.

The two subspecies of the gundi, *Ctenodactylus gundi gundi* and *Ctenodactylus gundi vali*, have probably had an evolutionary history similar to that of *Psammomys obesus* and *Psammomys vexillaris*, except

that in *Ctenodactylus*, the isolated population has not yet attained full species status.

*Ctenodactylus gundi vali* represents a population that originally became isolated from a population of *C. g. gundi* and has since continued to evolve independently in the more inland areas of Libya. As far as is known, the range of *C. g. gundi* in Libya is limited to rocky escarpments of the Gebel Nefusa and that of *C. g. vali* to larger wadis and occasional rocky outcroppings of the steppe region of northeastern Tripolitania. Both subspecies are clearly allopatric, and it is doubtful that the two forms would interbreed if they were to make contact. Morphological differences between the two populations are more on the level of subspecific distinctness. For the present, it seems best to regard *Ctenodactylus gundi vali* as an incipient species closely approaching full species status.

The dormice of Libya, by virtue of their apparent rarity and disjunct distribution, present a distributional pattern differing markedly from that of other Libyan rodents and demonstrate clearly the effects of geographic isolation on evolutionary processes.

The three subspecies of the Libyan dormouse, *Eliomys quercinus*, are geographically, morphologically, and ecologically distinct and illustrate the modern concept of the biologically defined polytypic species. In the past, the subspecies *E. q. tunetae* and *E. q. cyrenaicus* have at one time or another been regarded as full species by taxonomists. Until very recently the genus *Eliomys* was considered to represent a polytypic genus composed of several distinct species distributed in Europe (*Eliomys quercinus*), North Africa (*Eliomys munbyanus* and *Eliomys lerotinus*), and the Middle East (*Eliomys melanurus*). These various isolated, morphologically distinct "species," in addition to a new subspecies, *Eliomys quercinus denticulatus* from the Fezzan, are now regarded as subspecies of a single polytypic species, *Eliomys quercinus*.

The discontinuous distribution of these subspecies of *E. quercinus* is suggestive of a pattern expected for full allopatric species. In most cases, these allopatric subspecies show an amount of morphological distinctness typical of sympatric species. Because species normally consist of a series of continuous or discontinuous local populations and each population is composed of individuals with a different genetic constitution, a polytypic species would be expected to contain individual populations differing in phenotypic expressions. The morphological dissimilarity among the various "allopatric subspecies" of *E. quercinus* is not suggestive of specific differences but expresses, instead, a highly variable species gene pool. The ranges of *Eliomys quercinus tunetae* and *Eliomys quercinus cyrenaicus* include the Gebel Nefusa and the Cyrenaican Plateau respectively, while *Eliomys*

*quercinus denticulatus* is confined to the Fezzan. Such a discontinuous distribution for members of the same species is not in agreement with modern evolutionary concepts. Mayr (1931) has proposed the term semispecies for such widely separated allopatric members of the same species which normally differ so strikingly in morphological characters that reproductive isolation can almost be assumed. If one subscribes to Mayr's classification, all of the dormice of Libya, which are presently recognized as subspecies of a single species, *Eliomys quercinus*, would be regarded as morphologically distinct semispecies of a single, monophyletic superspecies.

The subspecies *Gerbillus gerbillus aeruginosus*, *Gerbillus campestris patrizii*, *Jaculus deserti vastus*, and *Jaculus jaculus cufrensis* also represent geographic isolates, but their ranges are located well within the limits of the ranges of their respective species, rather than on the periphery of the species range as in the above examples. Three of these subspecies occur only in the isolated oases of Cufra and Bzema in southern Cyrenaica, and *Jaculus deserti vastus* is known only from the Gebel el Harug el Asued of central Libya. All of these subspecies represent geographically isolated populations which are physically and genetically isolated from neighboring populations. As a result of this isolation, genetic exchange with neighboring populations is impossible. Thus, these populations have been subjected to a rapid repatterning of their gene pools with consequent reduction of variability and an increase in the rates of morphological differentiation and genetic fixation. Those subspecies restricted to Cufra Oasis are generally smaller in body and cranial size than other representatives of their respective species and, in this respect, represent a stage in clinal variation. *Jaculus deserti vastus* is significantly larger in body size than other representatives of this species in Libya. These rodent populations in Cufra and the Gebel el Harug el Asued illustrate clearly the significance of geographic isolation in the evolutionary process.

In summary, habitat segregation could have led to the splitting of the gene pool of parental species with subsequent development of other biological and behavioral differences. Spatial isolation of these populations has tended to further increase these differences, resulting originally from ecological (or habitat) isolation.

The populational structure of Libyan rodents is characterized by two primary structural components: geographically isolated populations and, less frequently, a series of contiguous populations that show progressive changes in morphological characters (clines). In some cases, where the ranges of two subspecies meet, there are zones of intergradation containing individuals intermediate in morphological characters.

## Zoogeographical Considerations

### Effects of the Pleistocene on the Dispersal of Saharan and Libyan Rodents

No account of Libyan (or Saharan) mammals should minimize the effects of the Pleistocene upon them and its obvious role in having influenced their present and past distribution. Henry Fairfield Osborn (1915, p. 225) summarized the importance of this period in North Africa by stating "Thus in no region of the world have more profound changes occurred during and since Pleistocene times than in Africa north of the Sahara Desert." In fact, it is probably true that most of the present distributional patterns of Libyan rodents are directly related to Pleistocene climates.

The Pleistocene was characterized by widespread glaciation in the northern parts of the world. As a response to broad climatic fluctuations during this period, four successive glaciations (in the northern hemisphere) alternated with milder interglacial periods following the withdrawal of the ice sheets. Estimates vary regarding the duration of the Pleistocene, but it probably endured for perhaps 1,000,000 years. The time of the withdrawal of the last continental glaciation is also not firmly fixed, and estimates range from 10,000 to 25,000 years.

Widespread glaciation in northern and southern latitudes was not the only manifestation of prevailing cold during the Pleistocene. Temperatures in the North Temperate Zone are thought to have been significantly lower than those of the present. This lowering of the temperature was probably synchronous over most of the Northern Hemisphere (Flint, 1947). During the intervening interglacial periods, climates were apparently warmer and sometimes drier than those of the pluvial periods.

As a result of lower prevailing temperatures, the amount of rainfall increased significantly over much of the world, and there was an accordant shifting of the temperate rain zones into the low latitude, subtropical deserts.

These changes in the Pleistocene climate produced manifold changes in the physical configuration in many regions of the Northern Hemisphere. Lakes in the arid portions of all continents increased in size and became reduced in rhythm with the advance and recession of the successive glacial stages. The Dead Sea, the great saline lakes of Asia (the Caspian, Aral, and Lake Balkash), and the large lakes of East Africa have lacustrine deposits high above their present shorelines, indicating marked expansion during the Ice Age, followed by shrinking during dry interglacial periods.

As glacial ice accumulated or receded on the continents, there was a synchronous lowering or raising of sea level throughout the world.

Thus, continents having broad continental shelves were increased or decreased considerably in area. The magnitude of this fluctuation of sea level has been estimated to have reached 100–120 meters during the height of glaciation (Darlington, 1957; after Kuenen, 1950).

Even today, there are abundant indications of Pleistocene glaciation. The higher peaks of the Caucasus and Elburz Mountains near the Caspian Sea in Southwest Asia contain glacial remnants. Portions of the Alps of central Europe are still enveloped in ice, and the Pyrenees of northern Spain have small glaciers. East Africa has residual glaciers on Mount Kenya, Mount Kilimanjaro, and on the Ruwenzori Range, all of which are almost astride the equator.

In response to these marked changes in temperatures during the Pleistocene, marked changes took place in the underlying patterns of floral and faunal distributions. In the Northern Hemisphere, the unglaciated areas south of the "ice front" were profoundly affected by periodic changes in Pleistocene climate. Widespread migrations of plants and animals occurred as a result of the gradual shifting of climatic zones along the glacial front. During the moist pluvial periods forest dwelling animals dispersed southward, while during the dry interpluvial periods animals typical of the steppe and desert regions migrated northward. Throughout the Pleistocene, there was a north-south shifting of the flora and fauna in concert with the four successive advances and withdrawals of the ice sheets.

During the pluvial periods, with increased rainfall throughout the world, forests and prairies expanded, and during interglacial periods steppes and deserts increased in area. Some of this repatterning of floral and faunal elements resulted in development of geographic discontinuity owing to complex advance, retreat, readvance, and interspersion of migrating populations.

Pleistocene climatic changes affected especially the Mediterranean region of North Africa. The Saharan and central portions were also profoundly affected. Evidence is widespread in North Africa and the Sahara to support climatic fluctuations during the Pleistocene.

According to Flint (1947; after Brooks, 1932), in the Saharan region of North Africa, two moist stages, interpreted on the basis of fossil mammals, are separated by a period of aridity indicated by an accumulation of gypsum in the soil. The numerous dry watercourses (wadis) in the Sahara suggest that permanent streams were present during a pluvial stage when the amount of rainfall was greater than it is today.

The occurrence in northern Africa of fossil mammals characteristic of markedly different climatic zones supports other evidences that

climatic patterns shifted in relation to the colder, moister pluvial and warmer, drier interpluvial stages of the Pleistocene.

The most recent study of the effects of the Pleistocene in Libya is that of McBurney and Hey (1955), entitled "Prehistory and Pleistocene Geology in Cyrenaican Libya." They consider the terraces on the northern side of the Gebel Achdar of extreme northern Cyrenaica to represent "ancient wave-cut platforms," and the cliffs to be also of marine origin. They therefore recognize six (or possibly seven) different shorelines corresponding to the number of terraces and the nature of their deposits. They propose two deductions (p. 68) regarding the manner of formation of these ancient shorelines. The first of these postulates involves a series of "successively lower altitudes at which sea-level halted, for a considerable length of time in each case, before reaching its present position." These altitudes are estimated by McBurney and Hey (p. 68) to consist of successive levels at: 140–200 meters (possibly representing two separate stages), 79–90, 44–55, 35–40, 15–25, and 6 meters. The second postulate considers the period in which these terraces were formed to have been one of "almost complete tectonic stability."

This evidence from northern Cyrenaica indicates that sea-level fluctuations from the highest level in Pliocene times to the lowest 6-meter level were punctuated by a series of intermediate shorelines probably corresponding to the pluvial and interpluvial climatic changes of the Pleistocene. McBurney and Hey conclude (p. 137) that during the Pleistocene the climate of the Gebel Achdar "was influenced profoundly," especially during the last continental glaciation (Würm glaciation).

In addition to establishing the pattern and sequence of ancient shorelines in Cyrenaica, McBurney and Hey (1955) conducted extensive diggings in the Wadi Derna and in two caves in northern Cyrenaica. The fossil mammals unearthed as a result of these investigations were reported by Bate as an appendix to the archeological text by McBurney and Hey (1955). These fossil mammals are largely represented by fragments, but 15 species have been identified, most of which shed interesting light on the Pleistocene mammalian fauna of northern Cyrenaica and North Africa.

Of particular interest to zoogeographical considerations in Libya was the discovery in northern Cyrenaica of fossils of the field mouse, *Apodemus* Kaup; the dormouse, *Eliomys;* a gerbil *Gerbillus*, and a vole, *Microtus*. All except *Apodemus* occur in Cyrenaica today, and these fossils probably represent earlier Pleistocene forms of the species occurring today in Cyrenaica. The field mouse, *Apodemus*, is now restricted in Africa to Algeria and northern Morocco.

The remains of the fossil Cyrenaican vole were described as a new species, *Microtus cyrenae*, by Bate (in McBurney and Hey, 1955,

p. 280). These fossil voles from Cyrenaica and a fossil *Ellobius* Fischer from the Pleistocene deposits in Algeria and Tunisia constitute the only known fossil records of the Microtinae in Africa. Members of the genus *Ellobius* are now restricted to Eurasia, but in Cyrenaica, a modern vole (*Microtus mustersi*) has persisted into modern times. According to Bate, this Pleistocene vole, which is known from 63 specimens consisting of teeth and fragments of jaws, differs from the modern *Microtus mustersi* primarily in having shorter and narrower cheek teeth with smaller reentrant angles. Bate concluded that *M. cyrenae* belongs to the *Microtus guentheri* group, which also includes *Microtus mustersi* and *M. philistinus* of Palestine.

According to Bate, the remains of voles were distributed through four successive levels of the Hagfet ed Dabba Cave, which would indicate an occupation of considerable duration in Cyrenaica and suggests an early Pleistocene arrival of voles into Cyrenaica.

This discovery of fossil voles in Cyrenaica, coupled with the present distribution of members of the *M. guentheri* group in the Middle Eastern countries, supports my hypothesis (and also that of Bate) that much of the Eurasiatic fauna of North Africa entered by way of the eastern Mediterranean countries and the Isthmus of Sinai sometime during the Pleistocene.

Probably the most unequivocal example of a Pleistocene relict is the vole, *Microtus mustersi*, of the Cyrenaican Plateau and adjacent coastal plain. These Libyan voles are the only living representatives of the subfamily Microtinae on the African continent and clearly represent a marginal intrusion of the Eurasian rodent fauna into North Africa. Today the nearest populations of *Microtus* occur in the Middle East and in Turkey. During the pluvials, suitable moist habitats probably were continuous along the coastal areas of northern Egypt, thus facilitating the dispersal of voles. Apparently, owing to the return of arid conditions during the following interpluvial period, the coastal areas of Egypt became dry, as they are today, and no longer afforded suitable habitats.

The Cyrenaican Plateau, by virtue of its higher elevation and more mesic habitats, must have served as a refugium for voles throughout the arid interpluvial periods. With the gradual return of less arid conditions to North Africa and Cyrenaica, voles reentered the Libyan coastal plain, while the Egyptian coastal plain still remains dry and unfit for them.

In addition to fossil rodents, several other genera of fossil mammals were discovered in these Pleistocene deposits of northern Cyrenaica. These include *Crocidura* Wagler, *Vulpes* Oken, *Panthera* Oken, *Bos* Linnaeus, *Ammotragus* Blyth, *Gazella* Blainville, *Hippotigris* Smith, and *Rhinoceros* Linnaeus. Of these genera, only the shrew (*Crocidura*) and the fox (*Vulpes*) are found in the region today, and they are con-

fined to the more arid regions. Today, members of the genus *Hippotigris* are restricted to Africa south of the Sahara, and those of the genus *Panthera* have a wide distribution, occurring in parts of central and southern Africa and in central, Southwest, and Southeast Asia. The genus *Rhinoceros* is today restricted to Southeast Asia.

Most fossil mammals from other parts of North Africa are related to species or genera now found only in the warmer tropical or subtropical regions of Africa or Asia. Pleistocene fossils from North Africa are listed by Osborn (1915) and include six species of elephants, including the mastodon; two species of rhinoceroses; horses, representing ancestral zebras; wild asses, similar to the Ethiopian ass; camels, showing no evidences of domestication; and cattle and buffalo. According to Osborn, the disappearance of the buffalo from North Africa at the beginning of the Recent Period was attributable to the increasingly dry conditions and the result of destruction by early man. Other large mammals known as fossils from North Africa consist of gnus (*Connochaetes* Lichtenstein); several species of the water buffalo (*Bubalus* H. Smith); nine species of gazelles (*Gazella*); oryx (*Oryx* Blainville); reedbuck (*Redunca* H. Smith); several kinds of eland (*Taurotragus* Wagner); dwarf antelopes or duikers (*Cephalophus* H. Smith); wild sheep similar to the extant North African Barbary sheep (*Ammotragus lervia* Pallas); and wild goats (*Capra* Linnaeus).

Fossil hippopotami have been found in ancient Pleistocene streambeds, one form being annectent to the existing hippopotamus of the Nile River. Other fossils include wild boar (*Sus* Linnaeus) and wart hogs (*Phacochoerus* G. Cuvier).

Fossil carnivores from the Pleistocene of North Africa include lions, leopards, hyaenas, jackals, and wolves. A fossil bear is known from Pleistocene deposits of Algeria, and machairodonts (sabre-toothed tigers) from the Pleistocene of Egypt. Fossil giraffe have been found associated with Paleolithic stone implements, and giraffe and a species of deer are depicted in rock drawings of Neolithic age in Algeria.

Judging from this impressive list of fossil mammals, much of the mammalian fauna of North Africa and probably also that of the Sahara, during the Pleistocene pluvials, resembled in composition the fauna which today is typical of the high African plains and of the tropical lowlands of central and southern Africa.

The buffalo (*Bubalus*), the rhinoceros (*Rhinoceros*), and the wild goat (*Capra*) clearly represent contingents of the Asian fauna into the Pleistocene of North Africa.

It is well established that animal (mammalian) populations do not preserve their distributional patterns indefinitely but are continually expanding and/or contracting in accordance with the prevailing

climatic regimen. At present, the Sahara Desert provides a decided deterrent to nondesert rodents, and local barriers even prevent the movements of desert rodents. Certainly, this was not the case throughout much of the Pleistocene.

From the above discussion it becomes evident that the climate of the Sahara during the Pleistocene, although somewhat arid, fluctuated in relation to climatic changes resulting from successive pluvial and interpluvial periods. During the moist pluvial periods, rodents now characteristic of the African veldt and savanna were able to disperse northward. Conversely, during the dry interpluvials, rodents of the steppes and deserts extended their ranges into the subtropical and tropical regions of Africa. The present distribution and composition of the African rodent fauna are probably a direct result of this intermingling and interdigitation of populations during Pleistocene time.

The present widespread distribution in Africa of the gerbils (*Gerbillus*) and spiny mice (*Acomys*), which are both restricted to arid habitats, probably is the result of widespread shifting of mammalian faunas during the dry interglacial periods. During interpluvials, various arid regions in Africa, now disjunct and separated by intervening areas of veldt and savanna or even tropical rain forest, probably were continuous and would have permitted genetic interchange among populations of gerbils that had previously been separated.

Unfortunately the fossil record of African rodents is meager, and many of the conclusions regarding distributional patterns of the Libyan and Saharan Pleistocene rodent faunas are conjectural. It seems reasonable to assume that at some period during the Pleistocene, the central and southern African rodent fauna, exclusive of that of the Congo Basin, dispersed far northward, probably to the northern limits of the continent.

Several extant species provide almost incontestable evidence of this widespread, northward displacement of this rodent fauna. The Barbary ground squirrel, *Atlantoxerus getulus* Linnaeus, and the Barbary striped mouse, *Lemniscomys barbarus* Linnaeus, of northern Morocco and Algeria clearly represent residual populations of the central African rodent fauna that advanced to the northern limits of the continent during a Pleistocene pluvial. Both of these species have all of their affinities with rodents occurring south of the Sahara. *Lemniscomys barbarus* is considered by some to be conspecific with populations of *Lemniscomys* Trouessart as far away as East Africa, and *Atlantoxerus getulus* is the only sciurid in North Africa; the nearest other African squirrels occur south of the Sahara.

In early Pleistocene times there were supposed broad land connections between Europe and North Africa and during the later Pleistocene, there were periodic fluctuations of sea levels occasioned by the

successive melting and accumulations of glacial ice during pluvial and interpluvial periods. During these times, rodents of European affinities could have easily entered North Africa by following the moist habitats appearing along the then exposed continental shelves or land bridges.

The mole rat, *Spalax ehrenbergi*, the field mouse, *Apodemus*, and the dormouse, *Eliomys quercinus*, are all clearly of European affinities and probably reached North Africa (and Libya) in this manner. The mole rat, *Spalax*, apparently migrated to North Africa following a dispersal corridor along the coastal regions of the Middle Eastern countries. An eastern entry of the mole rat into North Africa is supported by the fact that today they do not occur west of the Cyrenaican coastal plain of Libya. The direction from which the dormouse, *Eliomys*, entered North Africa is less distinct. Dormice are presently irregularly distributed along the coastal and steppe regions of North and Northwest Africa from Spanish Sahara to Sinai; they could have entered Africa by way of the Iberian Peninsula (Gibraltar) or could have followed the dispersal route of *Spalax* and entered Africa by way of the eastern Mediterranean countries. Dormice, field mice (*Apodemus*), and mole rats must have extended their ranges southward into Africa during one of the Pleistocene pluvials, because these species are not typically desert forms.

The fat-tailed sand rat, *Pachyuromys duprasi*, is typically an inhabitant of the well vegetated portion of the Saharan steppe. Yet, in Libya, a specimen was collected from the Wadi er Rueis near the Gebel el Harug el Asued, located several hundred kilometers within the Saharan interior. This disjunct population of fat-tailed sand rats likewise may represent a relict of the Pleistocene that moved southward when cooler, pluvial climates prevailed in the Sahara and with the return of aridity became stranded in this localized pocket of suitable habitat.

The genera *Meriones*, *Psammomys*, *Jaculus*, and *Allactaga* probably entered North Africa from Asia sometime late in the Pleistocene. All are typical of arid steppes or deserts and presumably evolved in the great steppes of central and southwest Asia during the Tertiary.

The jirds (*Meriones*) and the jerboas (*Jaculus* and *Allactaga*) must have extended their ranges southwestward from Southwest Asia during a dry interpluvial period and entered North Africa at a time when the Sahara was even more widespread than now. The sand rat (*Psammomys*), being less restricted to arid habitats, probably entered North Africa along the coastal regions of the Middle East, Sinai, and Egypt as they are presently defined. The genus *Psammomys* is today largely restricted to the coastal plain and the adjoining steppe of

Libya and is similarly restricted throughout its range in North Africa and the Middle East.

Recent entry of the genera *Meriones*, *Jaculus*, and *Allactaga* into Africa is indicated by their present distributional patterns. None is known from Africa south of the Sahara, and of the three genera, only *Jaculus* occurs virtually throughout the Sahara. The four-toed jerboa, *Allactaga tetradactyla*, is the only representative of the genus *Allactaga* in North Africa where it is limited to the coastal fringes of northern Egypt, and in Libya it occurs only as far west as the coastal plain of the Gulf of Sirte. Thus, this species apparently represents a recent arrival to the African rodent fauna. The more widespread distribution of jerboas of the genus *Jaculus* in the Sahara may reflect their greater ecological tolerance and may not indicate an earlier arrival into North Africa.

The genus *Meriones*, represented in Libya and North Africa by three species, *M. caudatus*, *M. crassus*, and *M. libycus*, and possibly by *M. shawi* of doubtful validity, has a peripheral distribution in relation to the Sahara. Members of this genus occur in all African countries bordering on the Mediterranean Sea and in the northern Sudan, Mauritania, and Spanish Sahara. With the exception of occasional encroachments into the northern Sahara, such as in the Libyan Fezzan, members of this genus inhabit a comparatively small portion of the Sahara.

Although suitable habitats are widespread in the isolated oases of southern Cyrenaica, such as Tazerbo and Cufra, jirds (*Meriones*) are unknown from this portion of Libya. Apparently, the great tracts of sand and sandy plains comprising the Sand Sea and Serir of Calanscio, and farther south, the Sand Sea of Rebianna, prevent the dispersal of members of this genus.

The distribution in North Africa, and particularly Libya, of the large gerbil, *Gerbillus pyramidum*, agrees closely with that of the genus *Meriones*.

The fact that these two kinds of rodents have been unable to surmount these present-day physical barriers, may indicate a recent entry for them into North Africa.

In considering faunal movements between Asia and Africa during the Pliocene-Quaternary period, the Nile River, because of its great length, large volume, and perennial nature, cannot be overlooked as a possible barrier. In modern times, the Nile River, in combination with the manmade Suez Canal, acts as a serious deterrent to the movements of rodents, particularly desert rodents. The movements of some species are retarded and, in some cases, curtailed by the Nile. The genera of North African rodents that appear to be most restricted

in their movements by the Nile include *Pachuromys* and *Sekeetamys* Ellerman. The effect of the Nile as a barrier to dispersal during modern times is further indicated by the following species of North African rodents which are represented by different subspecies occurring on opposite sides of the river: *Gerbillus henleyi; Meriones crassus; Psammomys obesus; Jaculus jaculus;* and *Gerbillus gerbillus.*

Judging from what is known of the past distribution of North African rodents, however, the barrier effect of the Nile has not been pronounced. The manner in which rodent populations in the past managed to surmount this apparent barrier is largely unknown, but it may be related to the developmental history of the river.

According to Said (1962, p. 24), an ancient pre-Miocene precursor of the Nile is evidenced by fluviatile sands and gravels that overlie the Eocene in Egypt. The modern Nile is therefore thought to represent a "much diminutive representative" of this ancient river. If this larger river was not the actual precursor of the Nile, it apparently followed a similar course and must have had a similar effect on the dispersal of rodents.

Opinions differ regarding the developmental history of the Nile. Said (1962) stated that the valley of the Nile in its present form was established following a regional uplift near the middle Miocene. The mechanics of the origin of the Nile Valley are not thoroughly understood, but available evidence indicates that a crustal disturbance probably established the course of the Nile. Some students feel that the Nile developed primarily as an erosional feature following a north-south syncline, while others favor a trough-fault origin. Recent drilling in the Nile Valley supports the theory that the Nile was eroded along a line of faulting and rifting (Said, 1962).

Most students of African geology agree that during the period between the end of the Cretaceous and middle Pleistocene important tectonic events resulted in the warping and uplifting of large portions of the African continent. This period was characterized by much faulting and deformation of the land surface. Toward the end of this long period of violent crustal disturbances, a Pliocene-Quaternary deformation produced additional movements along the large faults of the Red Sea and the great Rift Valleys of East Africa (Furon, 1960). These crustal disturbances presumably had pronounced effects in North Africa, including the Nile Valley.

In eastern Egypt, it is possible that these tectonic disturbances caused regional and local deformation of the surface configuration sufficient to alter the course of the Nile. Several large wadis, such as the Wadi Araba and the Wadi Ghuweibba, originate east of the Nile Valley and drain easterly into the Gulf of Suez. During a period of crustal disturbance one of these wadis could have usurped the function

of the Nile Valley, and the river would thus have entered the Gulf of Suez, rather than emptying into the Mediterranean Sea as it does today.

Other less tenable hypotheses include the diversion of the Nile along the great depressions of northern Egypt and entering the Mediterranean near the present city of Benghazi, Libya, on the Gulf of Sirte. It has also been suggested that the freshwater source for the chain of oases stretching irregularly across the central Sahara from Egypt to Morocco represents an "underground Nile" and thus a remnant of a previous course followed by the Nile River. The similarity of the fish fauna of these oases, many of which are today separated by vast tracts of desert, tends to support this hypothesis.

These latter changes in the course of the Nile are strictly conjectural, but some similar phenomenon is required to explain the present distribution of Saharan and southwest Asian rodents. In the absence of the Nile River as a barrier, the Arabian Peninsula, the Middle Eastern countries, and the Isthmus of Sinai would have provided a dispersal corridor allowing free interchange of Afro-Eurasian populations of rodents.

To establish breeding populations of desert rodents on the west side of the modern Nile in northwestern Egypt and northern Libya, a faunal immigration of relatively short duration would have been required. Following the reestablishment of the Nile along its present course, these "founder populations" of desert rodents in Egypt and Libya would have been isolated from the ancestral Eurasian populations and could have provided the "genetic pool" for the ensuing dispersal of these rodents throughout large portions of North Africa and the Sahara.

### Zoogeographical Relationships of the Rodents of the Sahara and Southwest Asia

During this study of the rodents of Libya it became necessary to examine specimens from adjacent parts of the Sahara and from the desert areas of Southwest Asia. As the study progressed, rather striking similarities were noted in the composition of the fauna of such widely scattered areas as the Saharan portions of North Africa, the deserts of Saudi Arabia, and the dry portions of the Middle East and Southwest Asia. Several genera of rodents occur exclusively in these arid portions of North Africa and Southwest Asia, and many others are widespread and occur only marginally in adjacent parts of Eurasia and Africa. Most of these genera have little taxonomic relationship with the rodents of marginal areas.

In view of the high degree of endemism shown by the rodent fauna of these desert regions of North Africa, Saudi Arabia, and Southwest

Asia, it seems appropriate to depart from conventional zoogeographic concepts and designate this arid belt of steppe and desert as a distinct zoogeographic subregion of the Palaearctic Realm. The name Saharo-Sindien Faunal Region is proposed for this new subregion of the Palaearctic, which coincides rather closely with the Saharo-Sindien Floral Region comprising the broad belt of steppe and desert vegetation occurring over this same geographic area.

More specifically, the Saharo-Sindien Faunal Region, referred to hereafter as the Saharo-Sindien Region, is delimited as: The Saharan portions of North Africa comprising the region from the Mediterranean coast southward to the broad belt of Saharan steppe of north-central Africa; the northern and central Sahara including Egypt, Libya, Tunisia, Algeria, Morocco, Spanish Morocco, and Spanish Sahara; the central and southern portions of the Sahara comprising portions of the Sudan, Chad, Niger, Mali, and Mauritania, and transforming farther south into the broad steppe region which extends into the central Sudan, southern Chad, northern Nigeria and Senegal; all of Saudi Arabia except possibly the extreme southwestern tip; the steppes and deserts of Sinai, Jordan, Syria, southeastern Turkey, and Iraq; the dry portions of Iran which comprise many desert and steppe areas, and the central plateau which includes the desolate Dasht-i-lut and Dasht-i-Kavir of eastern Iran; Baluchistan in both Iran and West Pakistan; the dry areas of northwestern West Pakistan; Afghanistan, excluding the central mountain complex; the Turkmen Plains, including the Kara Kum and Kyzyl Kum Deserts; and the great steppe and desert region east of the Caspian Sea, comprising the dry regions of the Ust Urt and the Russian provinces of Kazakhstan, Uzbekistan, and Turkmenia.

The most striking feature of the Saharo-Sindien Region is the prevailing aridity and the sparseness of the rodent fauna. This depauperate fauna consists of only 11 genera, surprisingly few considering the great size of the region. All of these genera are especially adapted to survive under dry conditions and even during periods of prolonged drought.

Of the 11 genera of rodents occurring in the Saharo-Sindien Region, almost all are endemic or, at best, occur only marginally in adjacent portions of Eurasia, India, or Africa. Genera most typical of the Saharo-Sindien Region include *Ctenodactylus*, *Massoutiera* Lataste, *Allactaga*, *Jaculus*, *Calomyscus* Thomas, *Gerbillus*, *Pachyuromys*, *Sekeetamys*, *Meriones*, *Psammomys*, and *Rhombomys* Wagner. The genera *Gerbillus*, *Meriones*, and *Jaculus* occur virtually throughout the entire Saharo-Sindien Region and are the most typical groups. The genera *Tatera* Lataste and *Acomys*, although widespread in the

Saharo-Sindien Region, are probably commoner in Africa south of the Sahara.

Some of the 11 genera are restricted to either the African or Asian portions, but none is confined exclusively to Saudi Arabia. Genera endemic to North Africa include *Ctenodactylus*, *Massoutiera*, and *Pachyuromys*. The Asian portion of the Saharo-Sindien Region is characterized by having the genera *Calomyscus* and *Rhombomys* restricted to it.

Some genera of rodents discussed above occur in adjacent parts of the Eurasian (Palaearctic), Oriental, and Ethiopian (Africa south of the Sahara) regions but usually are not widespread and probably represent marginal invasions. On the other hand, many typical Eurasian, Indian, and central African genera encroach upon various parts of the Saharo-Sindien Region. In most cases, these faunal encroachments have taken place in the more lush habitats provided by major river systems, mountain complexes, and coastal areas or have been linked with changes in the landscape wrought by man.

The nonrodent mammalian fauna of this geographic area provides strong supportive evidence for the hypothesis of a distinct Saharo-Sindien Faunal Region. Of great importance is the presence in the Saharo-Sindien Region of 23 endemic species of large (nonrodent) mammals. Mammals that are restricted to the Saharo-Sindien Region are:

| | |
|---|---|
| Sand fox | *Vulpes ruppelli* Schinz |
| Blanford's fox | *Vulpes cana* Blanford |
| Fennec | *Fennecus zerda* Zimmermann |
| Libyan striped weasel | *Poecilictis libyca* Hemprich and Ehrenberg |
| Sand cat | *Felis margarita* Loche |
| Persian fallow deer | *Dama mesopotamica* Brooke |
| Addax | *Addax nasomaculatus* Blainville |
| Arabian oryx | *Oryx leucoryx* Pallas |
| Scimitar-horned oryx | *Oryx tao* H. Smith |
| Dorcas gazelle | *Gazella dorcas* Linnaeus |
| Slender-horned gazelle | *Gazella leptoceros* F. Cuvier |
| Korin or red-fronted gazelle | *Gazella rufifrons* Gray |
| Dama gazelle | *Gazella dama* Pallas |
| Wild goat | *Capra hircus* Linnaeus |
| Barbary sheep | *Ammotragus lervia* Pallas |
| Lesser Moroccan hare | *Lepus atlanticus* de Winton |
| Arabian hare | *Lepus arabicus* Ehrenberg |
| Afghan pika | *Ochotona rufescens* Gray |
| Afghan hedgehog | *Hemiechinus megalotis* Blyth |
| Ethiopian hedgehog | *Paraechinus aethiopicus* Ehrenberg |
| Flower's shrew | *Crocidura floweri* Dollman |
| Egyptian pygmy shrew | *Crocidura religiosa* Geoffroy |
| Egyptian giant shrew | *Crocidura olivieri* Lesson |

Many additional species of mammals occur in parts of the Saharo-Sindien Region but are not restricted to it. These species include the jackal, *Canis aureus* Linnaeus; Indian grey mongoose, *Herpestes edwardsi* Geoffroy; striped hyaena, *Hyaena hyaena* Linnaeus; Pallas's cat, *Felis manul* Pallas; caracal lynx, *Felis caracal* Schreber; leopard, *Panthera pardus* Linnaeus; cheetah, *Acinonyx jubatus* Schreber; Asiatic wild ass (Onager), *Equus hemionus* Pallas; Persian gazelle, *Gazella subgutturosa* Güldenstaedt; mountain gazelle, *Gazella gazella* Pallas; ibex, *Capra ibex* Linnaeus; markhor, *Capra falconeri* Wagner; Algerian hedgehog, *Erinaceus algirus* Duvernoy and Lereboullet; long-eared hedgehog, *Hemiechinus auritus* Gmelin; Brant's hedgehog, *Paraechinus hypomelas* Brandt, and the pale grey shrew, *Crocidura pergrisea* Miller.

Being volant, bats are naturally less restricted by physical barriers and accordingly do not usually conform to standard mammalian distributional patterns. Nevertheless, several genera of bats are rather characteristic of the Saharo-Sindien Region, and several species occur exclusively in these parts of Asia and Africa. Bats most typical of this region belong to several families which are widely distributed throughout the temperate and tropical parts of the Old World. The genera of bats which are most common in the Saharo-Sindien Region are *Rousettus* Gray, *Rhinopoma* Geoffroy, *Taphozous* Geoffroy, *Nycteris* Cuvier and Geoffroy, *Rhinolophus* Lacepede, *Asellia* Gray, *Triaenops* Dobson, *Tadarida* Rafinesque, *Myotis* Kaup, *Eptesicus* Rafinesque, *Pipistrellus* Kaup, *Otonycteris* Peters, and *Plecotus* Geoffroy.

Although none of the above genera are endemic to the Saharo-Sindien Region, the following species are restricted to the area: *Rousettus arabicus* Anderson and de Winton; *Rhinopoma microphyllum* Brünnich; *Taphozous nudiventris* Cretzschmar; *Rhinolophus acrotis* Heuglin; *Triaenops persicus* Dobson; *Eptesicus walli* Thomas; *Eptesicus isabellinus* Temminck; *Pipistrellus deserti* Thomas, and *Pipistrellus ariel* Thomas.

The above lists show an amount of endemism in the large mammals and other nonrodent groups comparable to, and in some cases exceeding, that shown by the rodents. This peculiarity of the Saharo-Sindien mammalian fauna is probably largely attributable to the prevailing aridity of the region and the presence of vast tracts of desolate steppe and desert.

The genera of rodents which define the Saharo-Sindien Faunal Region differ as to origin and dispersal. Some are clearly of Asiatic origin, others show a closer relationship to the African fauna, while some appear to have developed in situ and bear little resemblance to the fauna of either Asia or Africa.

Today the genus *Gerbillus* is widely distributed throughout the steppes and deserts of Southwest Asia and is practically ubiquitous in the Sahara. Gerbils also occur sporadically throughout most of the African continent wherever desert or steppe conditions prevail and are represented by a broad spectrum of species. The greater number of species occurring south of the Sahara may reflect the more disjunct nature of suitable habitat in these less arid portions.

Owing to the greater number of species in Africa, probably the African continent has been the center of differentiation for members of the genus *Gerbillus*. The occurrence of gerbils in Southwest Asia, Saudi Arabia, and the Middle East therefore must be the result of the northward and eastward dispersal of this group through the Isthmus of Sinai sometime early in the Tertiary. This hypothesis of an early northward and eastward dispersal for members of this genus is supported by the discovery of fossil *Gerbillus* from the Pliocene of Asia (Darlington, 1957).

The genus *Acomys* is widely distributed in Africa but is limited in Asia to the steppe and desert regions south of the Caucasus Mountains and as far east as the Sind Desert of West Pakistan. Spiny mice occur also in the intervening deserts of Saudi Arabia and the Middle East. Because these mice are more restricted ecologically, their dispersal must have required long periods of time. As with *Gerbillus*, the African continent probably has served as the center of origin for spiny mice, and the populations of the Middle East and Southwest Asia represent invasions of the African fauna into Asia.

Although the genus *Jaculus* is ubiquitous in the Sahara, it clearly represents an intrusion of the jerboan fauna of central and Southwest Asia into North Africa. Jerboas are unknown from Africa south of the Sahara.

The four-toed jerboa, *Allactaga tetradactyla*, is restricted to the coastal areas of northern Egypt and northeastern Libya and is the only representative of the genus in North Africa. This genus occurs widely in temperate Asia ranging throughout Southwest Asia and extending north and east into the cold steppes of Russian and Chinese Turkestan and is represented by several species.

The genera *Jaculus* and *Allactaga* are the only African representatives of the Dipodidae. Temperate Eurasia, however, has 10 additional dipodid genera and a broad assemblage of species. Furthermore, the fossil record of Asia contains four genera of dipodid rodents extending as far back as the Miocene (Darlington, 1957). No fossil dipodids are known from North Africa.

The present distribution of the jerboan fauna of temperate Eurasia, strengthened by the rather extensive fossil record, provides convincing

285-134 O—68——5

evidence of an Asian origin for the family Dipodidae and the two genera occurring in Africa.

The genus *Meriones* is clearly of Asiatic origin and probably represents a recent arrival of the Eurasian fauna into North Africa. Members of the genus *Meriones* (jirds) are widely distributed in North Africa in Egypt, Libya, Algeria, Tunisia, and Morocco but are confined more to the northern portions of these countries. In Asia, several species belonging to this genus are widely distributed in parts of Transcaucasia, Russian Turkestan, Chinese Turkestan, Iran, Afghanistan, Baluchistan, and occur as far east as Manchuria and Mongolia.

The genus *Tatera*, although unknown from the entire North African coast and the Sahara proper, occurs extensively in Southwest Asia as the monotypic *Tatera indica* Hardwicke. In Africa south of the Sahara the genus is known polytypically. This hiatus in distribution of the genus is a zoogeographical enigma which is not readily soluble.

Africa may have served as the center of dispersal for the genus *Tatera*, or the genus may represent a comparatively recent invasion into Africa. The static nature of the genus in Asia, however, may be the result of prolonged isolation of a peripheral isolate which shows signs of genetic impoverishment and evolutionary decline. A static gene pool is indicated by the maintenance of a single monotypic species over such a large geographic area. The fact that in many parts of the range of *Tatera indica* it is closely associated with human agriculture suggests that this Asian species has indeed lost some of its original genetic variability.

In view of the extreme discontinuity in the range of the genus *Tatera*, the Asian and African complexes must have become isolated early in the Tertiary and have since evolved independently.

The greater number of African species of *Tatera*, the more variable nature of the populational gene pool, and the general similarity of its range to those of other genera thought to have evolved in Africa, seem to favor an African center of origin for the genus *Tatera*, but until the fossil record provides something more conclusive, I prefer to regard the geographic origin of *Tatera* with reservations.

In the preceding pages, discussion has dealt with those genera common to both the Saharan and Asian portions of the Saharo-Sindien Region. Other genera characteristic of this newly proposed zoogeographic region are confined either to the Saharan or Asian portions.

The family *Ctenodactylidae*, which comprises the genera *Ctenodactylus*, *Massoutiera*, *Pectinator* Blyth and *Felovia* Lataste, is probably the most unusual Saharan family. The genera *Ctenodactylus* and *Massoutiera* are exclusively Saharan, whereas *Pectinator* and *Felovia*

approach, respectively, only the southeastern and southwestern margins of the Sahara. The members of this distinctive family are regarded by most systematists as being related to the hystricomorph rodents and therefore have few relatives in Africa. Other hystricomorph genera in Africa, such as *Hystrix*, *Atherurus* Cuvier, *Thyronomys* Fitzinger, *Pedetes* Illiger, and *Petromys* A. Smith, are, except *Hystrix*, confined to Africa south of the Sahara. That the genus *Pectinator* is "doubtfully represented in the Pliocene of India" (Darlington, 1957, p. 392) strengthens the hypothesis of a Saharo-Sindien Faunal Region.

The fat-tailed sand rat, *Pachyuromys duprasi*, is apparently confined to the Saharan steppe of Egypt, Libya, Tunisia, Mauritania, and Algeria. This unique, monotypic genus is probably most closely related to *Meriones* but unlike the latter genus has undergone an in situ development in North Africa.

The range of the sand rat, *Psammomys obesus*, is usually more coastal than other jirdlike rodents and includes coastal northern Sudan in addition to North Africa, the Isthmus of Sinai, and adjacent Israel and Arabia. The genus *Psammomys*, although a significant element of the rodent fauna of North Africa, is related to the genera *Meriones* and *Rhombomys* and is probably of Asiatic origin.

*Sekeetamys calurus* Thomas, the bushy-tailed jird, known only from Sinai, Israel, and eastern Egypt, is probably the most localized in distribution of any of the species of Saharo-Sindien rodents. This species has apparently undergone a rapid in situ development in this restricted area owing to its narrow ecological tolerances.

Three monotypic genera, *Rhombomys*, *Calomyscus*, and *Nesokia*, are confined almost exclusively to the Asian portion of the Saharo-Sindien Region. *Rhombomys* ranges from Turkmenia and eastern Iran into Chinese Turkestan and Mongolia; *Calomyscus* is found in the dry foothill areas of Turkmenia, Iran, Afghanistan, and Baluchistan; the range of *Nesokia* extends from India and Baluchistan to Arabia and Egypt.

In addition to the endemic and characteristic genera and species of the Saharo-Sindien Region, several kinds of rodents have intruded into the peripheral desert areas of Southwest Asia from Europe, the high latitude steppes and deserts of Russia, and the subtropical parts of the Oriental region, while some typical European and African rodents have penetrated into peripheral Saharan portions of North Africa.

The squirrel *Spermophilopsis* Blasius; the dipodid genera *Salpingotus* Vinogradov, *Pygeretmus* Gloger, *Paradipus* Vinogradov, *Dipus* Zimmermann, and *Stylodipus* G. Allen; and the mole-vole *Ellobius* are

representatives of the central Asian fauna with Eurasian affinities and occur marginally in the Saharo-Sindien Region.

The palm squirrel *Funambulus* occurs in Baluchistan and represents an encroachment of the Indian fauna into the extreme southeastern portion of the Saharo-Sindien Region.

Examples of the European rodent fauna which have entered North Africa include the dormouse, *Eliomys quercinus;* the Palestine mole rat, *Spalax ehrenbergi;* the vole, *Microtus mustersi;* and the field mouse, *Apodemus sylvaticus* Linnaeus. As discussed earlier, these species probably entered North Africa during one of the pluvials of the Pleistocene.

The Barbary ground squirrel, *Atlantoxerus getulus,* the only North African squirrel, and the Barbary striped mouse, *Lemniscomys barbarus,* are notable exceptions in the North African fauna and are related to the fauna of central and southern Africa. These two species are limited respectively to the Algerian Atlas and to the less arid parts of Algeria and Morocco. The genus *Atlantoxerus* is monotypic, but *Lemniscomys* is composed of several central African species. Ellerman and Morrison-Scott (1951) consider this North African species of *Lemniscomys* to be conspecific with one of the central African species.

Some African rodents which encroach into portions of the southern Saharan steppe include: the sciurids *Euxerus* Thomas and *Heliosciurus* Trouessart; the dormouse *Graphiurus* Smuts; the cricetid genera *Taterillus* Thomas and *Desmodilliscus* Wettstein, and numerous murid genera including *Arvicanthis* Lesson, *Mastomys* Thomas, *Praomys* Thomas, and *Grammomys* Thomas.

The various penetrations of the European and African rodent faunas into marginal portions of the Sahara and the intrusions of the Eurasian and Indian faunas into portions of Southwest Asia do not refute the hypothesis of a Saharo-Sindien Faunal Region. The indigenous rodent fauna (and the nonrodent fauna) of these low latitude deserts of the Old World differs markedly from that of adjoining Eurasia, India, and Africa and clearly justifies the formation of this new zoogeographic region.

The rodent fauna of the Russian steppes and the high latitude deserts of Manchuria and Mongolia contains some genera which occur in the northern portions of Southwest Asia, particularly in the vast steppe region east of the Caspian Sea. Probably it was this arid region east of the Caspian Sea which served as the center of differentiation for most of the rodents now comprising the Saharo-Sindien Faunal Region. The rodent faunas of the Gobi Desert, the Takla Makan of Sinkiang, and other cold deserts of central Asia probably represent an outgrowth of the Saharo-Sindien fauna which has since become adapted to cold, arid climates.

## Conclusions

This study of Libyan rodents is based primarily on specimens obtained by the author during the period from October 1961 to July 1962 and is the first attempt to provide a comprehensive treatment of the taxonomy and distribution of the Libyan rodents based upon actual specimens and field experience.

Fifty-six kinds of rodents comprising 7 families, 14 genera, 28 species, and 48 subspecies occur in Libya. In this report, 20 subspecies are described as new, and 3 forms, *Gerbillus aureus*, *Meriones caudatus*, and *Jaculus deserti*, which had previously been regarded as subspecies, are elevated to full species.

Species belonging to the genera *Gerbillus*, *Meriones*, and *Jaculus* show the widest range of geographic and individual variation found among the Libyan rodent fauna. The polytypic species *Gerbillus campestris*, *Gerbillus gerbillus*, and *Jaculus jaculus*, each represented in Libya by 5 subspecies, are the most widely distributed and the most genetically variable of any of the Libyan rodents.

Libyan rodents usually do not conform to climatic or ecogeographical rules, such as Bergmann's or Allen's rule, and geographic variation in response to selective factors of the environment is most apparent in the cryptic coloration of the "substrate races" of *Gerbillus campestris* and *Meriones caudatus*.

The populational structure of Libyan rodents is characterized by two primary components. These are geographical isolates and, less frequently, a series of contiguous populations showing progressive change in morphological characters (clines). It is probable that in Libya most species have arisen as a result of the genetic divergence of peripheral isolates. Gradual speciation, as opposed to instantaneous speciation or macroevolution, has been the prevailing mode of speciation for Libyan rodents. Of the two types of gradual speciation, geographic, rather than sympatric, has played the primary evolutionary role.

Three faunal areas, which coincide roughly with the major physiographic, vegetative, and climatic features, are recognizable in Libya based on the distribution of the rodent fauna. Each of these faunal areas is divisible into two regional provinces according to the kinds of rodents most typical of each. The faunal areas of Libya and their provinces are: The Mediterranean Faunal Area which is comprised of the Coastal Plain Province and the Cyrenaican Plateau Province; the Saharan Steppe Faunal Area consisting of the Transitional Desert Province and the Tripolitanian Gebel Province; and the Saharan Desert Faunal Area which includes the Cyrenaican Desert Province and the Fezzanese Desert Province.

Local differentiation of Libyan rodents indicates the presence of four areas of potential endemism. These areas are the Cyrenaican Plateau and coastal plain of northern Cyrenaica, the Gebel Nefusa, the Fezzan, and Cufra Oasis.

The distribution and composition of the Saharan (and Libyan) rodent fauna has been profoundly influenced by the widespread shifting of mammal populations during the Pleistocene.

Owing to the similarities of the rodents of North Africa and Southwest Asia, and because of the high degree of endemism shown by them, the Saharo-Sindien Faunal Region is here proposed as a new zoogeographic region for this arid belt of steppe and desert. The genera of rodents defining the Saharo-Sindien Faunal Region differ as to origin and dispersal. The genera *Allactaga*, *Jaculus*, *Calomyscus*, *Meriones*, *Psammomys*, and *Rhombomys* are clearly of Asian origin. The genera *Gerbillus* and *Acomys* are apparently of African origin. The genera *Pachyuromys*, *Massoutiera*, and *Ctenodactylus* probably have developed in situ in North Africa.

The arid region east of the Caspian Sea possibly has served as the center of differentiation for most of the rodents comprising the Saharo-Sindien Faunal Region.

Interchange of Afro-Eurasian rodent faunas probably took place at a time when the Nile River was less effective as a disperal barrier than it is today.

## Systematic Treatment

### Plan of Treatment

The phylogenetic arrangement of the taxonomic categories from suborder to genus follows Simpson (1945). The species of each genus and their component subspecies are arranged alphabetically. The major genera are introduced by a detailed summary of their taxonomic history, and in the case of *Gerbillus*, *Meriones*, and *Jaculus*, keys are provided for the identification of the species. Owing to the lack of standardization of vernacular names of North African rodents and the inconsistency of their use by workers in the past, they have been omitted as formal headings and are employed only in a general sense.

The following procedure is employed in the accounts of species and subspecies:

1. The currently accepted binomial name combination in agreement with the "International Code of Zoological Nomenclature" (1961) is followed on the same line by the name of the author.

2. Original description: The original name is succeeded by the name of the author, a reference to the original account, the date on which the foregoing account was published, and the type locality in parentheses.

3. General distribution of species: The known distribution of the species in North Africa, Europe, and Southwest Asia is given under this heading.

4. Distribution in Libya: The entire range of the species in Libya, including political provinces or portions thereof, based upon specimens examined and published records.

5. Distribution of the subspecies in Libya: Each subspecies is arranged alphabetically and its range in Libya briefly outlined according to physiographic features and political boundaries.

6. Published records: In this section all known records from the literature are summarized for each political province. For each province the records are arranged chronologically, and when two or more localities are represented they are listed in alphabetical order. The author's name and the date of publication appear in parentheses following each locality record or series of localities.

7. Comparisons: Comparisons are limited to those species which are easily confused with each other and separable only by subtle characters. Because most of the Libyan species of rodents are quite distinct morphologically, this section is frequently omitted.

8. Remarks: The taxonomic history of the species is covered in this section, and problems and events relating to systematics and dispersal are discussed.

9. Ecological observations: This section deals with the habitat requirements of the species and discusses other species of rodents which share the same habitat.

After the general discussion at the species level, the following procedure is employed in the treatment of the subspecies:

1. The currently accepted trinomial name combination is followed on the same line by the name of the author.

2. Original description: The original name is succeeded by the author, a reference to the original account, the date on which the foregoing account was published, and the type locality in parentheses.

3. Specimens examined: Specimens examined, unless otherwise qualified, are skins and skulls. The total number examined is given first; this is followed by the name of the province, the exact locality of capture, and the exact number from this locality. Collecting sites from Cyrenaica are listed first, followed by those from Tripolitania and the Fezzan. Within the provinces, collecting sites are arranged in sequence from north to south. Those having the same latitudinal coordinate are arranged from east to west.

Sight and verbal records and records of occurrence from the literature are included, respectively, in the sections on "remarks" and "published records." In a few cases, specimens were examined from the mammal collections of the British Museum (Natural History), London, and

Muséum National d'Histoire Naturelle, Paris; these are indicated, respectively, by the abbreviations BM and MNHN. Unless otherwise stated, all other catalog numbers represent specimens in the collections of the Division of Mammals, United States National Museum, Smithsonian Institution, Washington, D.C.

The distribution maps, in most cases, indicate localities from which I examined specimens. These are indicated by solid black circles. The few localities showing published records are indicated by a solid black triangle. The shaded portions of the maps (vertical and horizontal lines) indicate the range of a given species or subspecies in Libya, as judged from known records of occurrence. No species or subspecies occurs in all parts of the shaded area but is limited to areas of suitable habitat.

4. Measurements: All measurements are given in millimeters and are of adults unless otherwise indicated. Given first are the four standard body measurements: Total length (from the tip of the rostrum to the end of the last caudal vertebra); length of tail (from the proximal end of the first caudal vertebra to the distal end of the last caudal vertebra); length of hind foot (from the proximal end of the calcaneus to the end of longest claw); length of ear (from the base of the notch to the distal end of the pinna). Cranial measurements, taken by dial calipers, follow the external measurements. When the measurements of more than three specimens are given, they are listed as average and extremes. If there are three specimens or less, their measurements are listed individually, and the museum catalog number is given for each.

5. Diagnosis: Capitalized color terms are those of Ridgway "Color Standards and Color Nomenclature" (1912). Noncapitalized color terms are employed in those instances where a detailed color description was deemed unnecessary. Whether the description represents winter or summer pelage is specified in those subspecies where seasonal pelage colors differ significantly. In most cases detailed descriptions involving the gross features of the skull and, in some cases, characters useful in specific and subspecific diagnosis are given.

6. Comparisons: Specimens from Libya are compared with those representing marginal subspecies to determine their true taxonomic position. Whenever possible, paratypical and topotypical specimens are used in these comparisons to better validate the assignments. In some instances, comparisons were made with all subspecies comprising a given species, which frequently necessitated examination of specimens from Egypt, Sudan, Tunisia, and Algeria.

7. Remarks: All systematic problems and enigmas are considered under this heading. Evidences of intergradation with other subspecies and their interpretation are within the province of this section. Also

considered are the implications of physiography and geography and their roles in generating evolutionary developments and morphological differences. Plausible avenues of dispersal are considered whenever affinities and relationships with other populations are held unaccountable. Range extensions are also included here.

8. Ecological observations: This section provides information on behavior and some aspects of natural history with emphasis on habitat preferences. Considerable detail is given to the types of plants and the nature of the substrate forming the various habitats.

9. Description of new subspecies: The format for describing new subspecies is identical to that used for the accounts of recognized subspecies except the newly proposed subspecific name is followed by the designation of the holotype. Data relating to the holotype are recorded in the following sequence: Sex; an indication as to whether the holotype represents skin, skull or both; museum of repository (USNM=United States National Museum); catalog number; exact collecting locality; date of collection; name and original field number of the collector.

10. Analysis of variation and the diagnostic characters of the species and subspecies: In an effort to determine the extent of individual and geographic variation within the various species and subspecies of Libyan rodents and to ascertain the measurable characters which distinguish them, specimens were selected from localities which represented the most typical representatives of the particular taxon and were then treated statistically. In some instances, on the specific level, it was necessary to pool specimens from several localities in order to increase sufficiently the size of the sample and thus increase statistical reliability. Generally, however, the analyses are based on specimens from a single locality. In determining the amount of morphological divergence and variation within and between subspecies, paratypical or topotypical specimens were used whenever possible. In all of the analyses and comparisons, the sexes have been treated separately to prevent erroneous conclusions arising from sexual dimorphism.

Before taxonomic variation could be determined for a population of rodents, the amount of nongeographic variation had to be taken into account. In this latter category are included random genetic variation inherent in the gene pool of the species or subspecies and the differences resulting from growth, age, sex, seasonal changes, pathological conditions, and other kinds of variation related to known stimuli. To prevent misleading interpretation of the variation associated with geographical distribution, extreme care was taken to insure that all specimens in the sample were of comparable age, and those suspected of showing seasonal characters, pathological conditions, or

other abnormalities were not used. Series of specimens were analyzed by standard statistical methods which involved computation of the arithmetic mean, standard deviation, and standard error of the mean.

In some instances, in which the absolute size of a character is the same in two taxa, scatter diagrams are employed to demonstrate differences in the relative size of this character.

Graphical methods employed here are patterned after those given by Hubbs and Hubbs (1953). The range of variation is shown by a heavy horizontal line, and the mean is indicated by a sharply pointed triangle.

The black portion of each bar comprises two standard errors of the mean on either side of the mean. The entire bar (black and white portions) constitutes one standard deviation on either side of the mean. In samples of four specimens, two standard errors and one standard deviation have the same value, and the entire bar is therefore black. Samples of less than four specimens were not treated statistically. In these cases, the range of variation is shown by a heavy horizontal line, the mean is indicated by a sharply pointed triangle, and the bar is omitted. A single triangle indicates that only one specimen is represented. The standard deviation (S.D.) indicates

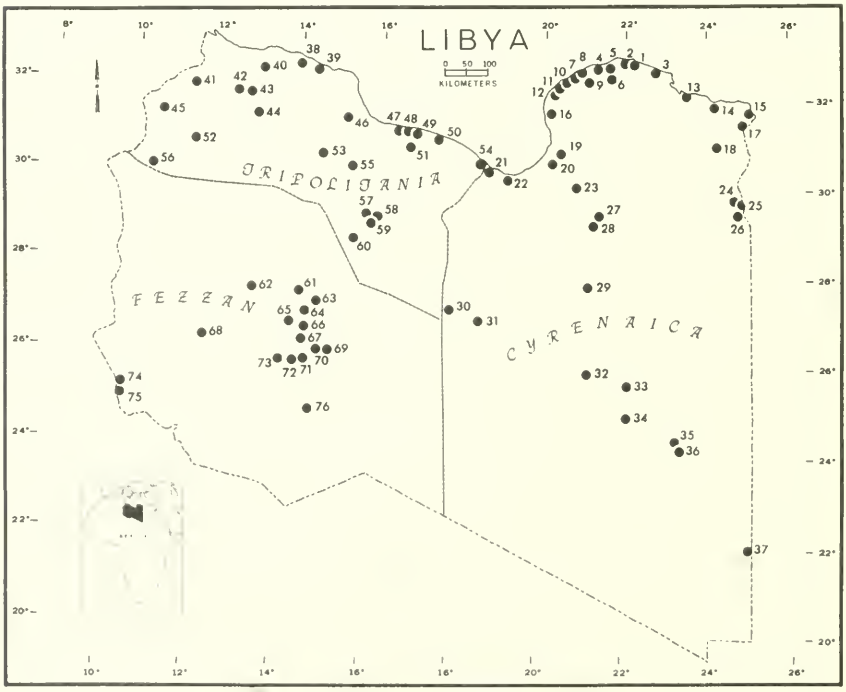


FIGURE 3.—Principal collecting localities.

the dispersion about the mean, and the standard error (S.E.) indicates the degree of reliability of this dispersion.

According to Hubbs and Hubbs (1953), a large amount of overlap of the dark bars (S.E.) indicates a low reliability of the observed difference between two samples, and any appreciable separation of these bars indicates a high reliability. These same authors recommend plotting one standard deviation on either side of the mean to indicate probable subspecific difference by a nonoverlap of the bars. This method indicates an 84 percent separation of the specimens by the character being analyzed.

## Gazetteer of Principal Collecting Localities

### Cyrenaica

| | | Locality number |
|---|---|---|
| Agedabia, 10 km S | (30° 42 N, 20° 19 E) | 19 |
| Agedabia, 20 km SW | (30° 36 N, 20° 07 E) | 20 |
| El Agheila, 65 km WNW | (30° 27 N, 18° 34 E) | 21 |
| El Agheila, 5 km W | (30° 15 N, 19° 07 E) | 22 |
| Augila | (29° 09 N, 21° 14 E) | 28 |
| Bardia, 5 km W | (31° 46 N, 25° 06 E) | 15 |
| Benghazi, 8 km N | (32° 11 N, 20° 06 E) | 12 |
| Bzema Oasis | (24° 55 N, 22° 02 E) | 34 |
| Fort Capuzzo, 10 km SW | (31° 31 N, 24° 59 E) | 17 |
| Coefia, 2 km N | (32° 14 N, 20° 11 E) | 11 |
| Derna, 5 km SE | (32° 44 N, 22° 40 E) | 3 |
| Ain el Gazala, 11 km E | (32° 08 N, 23° 31 E) | 13 |
| Gerdes, 10 km N | (32° 24 N, 20° 56 E) | 9 |
| Gheminez | (31° 39 N, 20° E) | 16 |
| Gialo | (29° 15 N, 21° 14 E) | 27 |
| Gialo, 150 km S | (27° 43 N, 21° 05 E) | 29 |
| Giarabub | (29° 45 N, 24° 33 E) | 24 |
| Giarabub, 24 km SSE | (29° 34 N, 24° 42 E) | 26 |
| El Giof, Cufra Oasis | (24° 11 N, 23° 19 E) | 36 |
| Bir el Gobi, 60 km S | (31° N, 24° 13 E) | 18 |
| Gubba, 12 km NW | (32° 51 N, 22° 10 E) | 1 |
| Bir el Harasc | (25° 30 N, 22° 06 E) | 33 |
| Gebel el Harug el Asued, 200 km SE Zella | (27° 05 N, 17° 45 E) | 30 |
| El Hauuari, Cufra Oasis | (24° 21 N, 23° 14 E) | 35 |
| Wadi el Kuf, 13 km WSW Messa | (32° 39 N, 21° 29 E) | 5 |
| Maraua, 7 km E | (32° 31 N, 21° 28 E) | 6 |
| Merg (=Barce) | (32° 30 N, 20° 54 E) | 8 |
| Messa, 35 km W | (32° 44 N, 21° 13 E) | 4 |
| Wadi er Rueis, 340 km WNW Tazerbo Oasis | (26° 52 N, 18° 31 E) | 31 |
| Gasr es Sahabi | (30° 01 N, 20° 45 E) | 23 |
| Susa (=Apollonia), 11 km SW | (32° 50 N, 21° 52 E) | 2 |
| Tazerbo Oasis | (25° 45 N, 21° 09 E) | 32 |
| Tocra, 2 km W | (32° 31 N, 20° 34 E) | 7 |
| Tocra, 20 km SW | (32° 24 N, 20° 24 E) | 10 |

## Gazetteer of Principal Collecting Localities—Continued

### Cyrenaica—Continued

| | | Locality number |
|---|---|---|
| Tobruch, 20 km E | (31° 58 N, 24° 08 E) | 14 |
| Bahr el Tubat, 21 km ESE Giarabub | (29° 36 N, 24° 53 E) | 25 |
| Ain Zueia, Gebel Uweinat | (21° 53 N, 24° 50 E) | 37 |

### Tripolitania

| | | |
|---|---|---|
| Bir Allagh, 55 km SW | (30° 45 N, 11° 31 E) | 52 |
| Wadi Bey, 45 km W Bu Ngem | (30° 35 N, 14° 55 E) | 53 |
| Bu Ngem, 30 km S | (30° 19 N, 15° 19 E) | 55 |
| El Cusher | (31° 01 N, 17° 32 E) | 50 |
| Cussabat, 5 km W | (32° 35 N, 13° 58 E) | 38 |
| Derg, 5 km E | (30° 12 N, 10° 29 E) | 56 |
| Gharian, 25 km N | (32° 25 N, 13° 03 E) | 40 |
| El Gheddahia, 7 km S | (31° 23 N, 15° 12 E) | 46 |
| Ain Hammam | (29° 09 N, 15° 47 E) | 57 |
| Hun, 2 km SW | (29° 07 N, 15° 55 E) | 58 |
| Gebel Limhersuk | (30° 45 N, 16° 45 E) | 51 |
| Marble Arch, 15 km WNW | (30° 33 N, 18° 28 E) | 54 |
| Mizda, 5 km N | (31° 30 N, 12° 59 E) | 44 |
| Nalut, 40 km ENE | (32° 01 N, 11° 22 E) | 41 |
| Rumia, 20 km E | (31° 58 N, 12° 44 E) | 43 |
| Rumia, 3 km W | (31° 59 N, 12° 30 E) | 42 |
| Sinauen, 40 km N | (31° 24 N, 10° 39 E) | 45 |
| Sirte, 20 km E | (31° 11 N, 16° 47 E) | 49 |
| Sirte, 5 km E | (31° 12 N, 16° 38 E) | 48 |
| Sirte, 12 km W | (31° 13 N, 16° 27 E) | 47 |
| Socna, 5 km S | (29° 01 N, 15° 45 E) | 59 |
| Gebel es Soda, 60 km S Socna | (28° 37 N, 15° 28 E) | 60 |
| Zliten, 12 km W | (32° 29 N, 14° 26 E) | 39 |

### Fezzan

| | | |
|---|---|---|
| El Abiad, 60 km SW Sebha | (26° 46 N, 14° E) | 65 |
| Umm el Araneb | (26° 08 N, 14° 45 E) | 70 |
| Brach | (27° 33 N, 14° 15 E) | 61 |
| Edri | (27° 32 N, 13° 12 E) | 62 |
| El Gatrun | (24° 57 N, 14° 39 E) | 76 |
| Ghat, 20 km N | (25° 08 N, 10° 11 E) | 75 |
| Goddua, 26 km N | (26° 38 N, 14° 25 E) | 66 |
| Goddua | (26° 25 N, 14° 19 E) | 67 |
| Meseguin | (26° 09 N, 14° 58 E) | 69 |
| Murzuch, 28 km E | (25° 55 N, 14° 12 E) | 72 |
| Murzuch | (25° 55 N, 13° 55 E) | 73 |
| Sebha | (27° N, 14° 27 E) | 64 |
| Serdeles, 55 km SSW | (25° 19 N, 10° 15 E) | 74 |
| Temenhint, 30 km NE Sebha | (27° 13 N, 14° 38 E) | 63 |
| Traghen | (25° 59 N, 14° 26 E) | 71 |
| Ubari, 75 km W | (26° 25 N, 12° 02 E) | 68 |

## Family Cricetidae

## Subfamily Microtinae

### Genus *Microtus* Schrank

#### *Microtus mustersi* Hinton

*Microtus mustersi* Hinton, Ann. Mag. Nat. Hist., ser. 9, vol. 18, p. 305, September 1926 (Merj [=Barce], Cyrenaica).

General distribution of species. Libya, on the Cyrenaican Plateau and adjacent coastal plain.

Specimens examined. Six, from Cyrenaica: 10 km SW El Faidia, 1 (skin, skull, and skeleton); Merg (=Barce), 2 (BM; 1 skin only); 5 km W Tocra, 3.

Published records in Libya. Cyrenaica: Barce (Hinton, 1926).

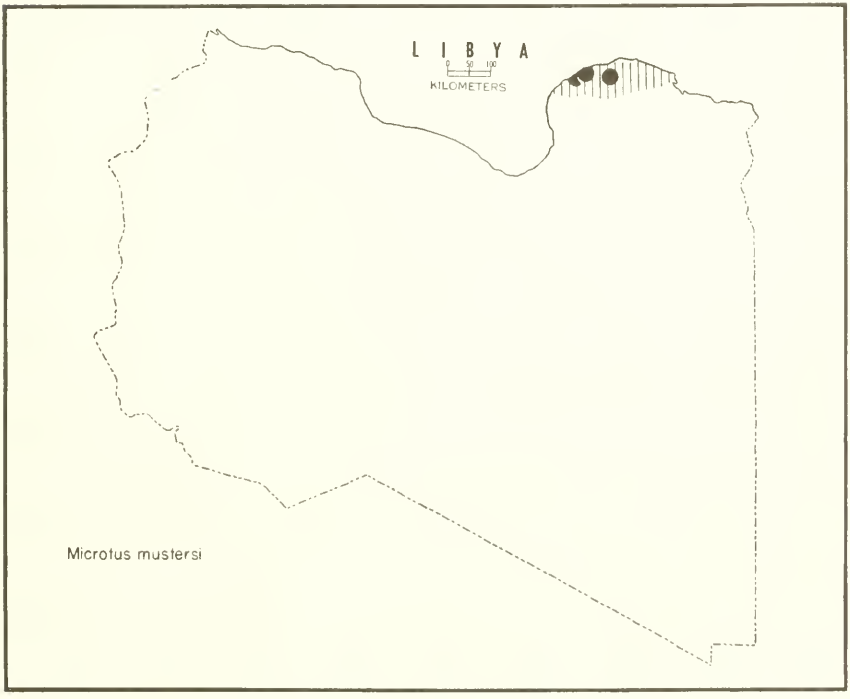


Figure 4.—Distribution of *Microtus mustersi*.

Measurements. The measurements of two immature males, 325019 and 325021, and of an adult male, 325020, from 5 kilometers west of Tocra, Cyrenaica, are respectively: Total length 131, 130, 130; length of tail 30, 25, 31; length of hind foot 18, ?, 18; length of ear 11, 10, 12; condyloincisive length of skull 24.6, 25.8, 26.5; greatest breadth across zygomatic arches 14.4, 14.5, 15.9; length of nasals 6.7, 6.9, 6.7; least interorbital breadth 3.7, 3.9, 3.8; crown length of upper molariform toothrow 5.9, 6.4, 6.4; greatest breadth across braincase 11.4, 11.7, 12; length of incisive foramina 4.4, 4.5, 4.5.

Diagnosis. Entire dorsum uniformly colored Buckthorn Brown, becoming slightly paler on flanks and sides and forming a distinct contrast with the white-tipped hairs of the venter; all hairs of dorsum and venter Plumbeous basally; pinnae of ears short and inconspicuous, Prout's Brown, sparsely haired, and with several long brownish hairs partially covering ventrolateral surfaces; eye ring absent; vibrissae relatively short and fine and composed of both light and dark individual hairs; dorsal surfaces of forelegs, hindlegs, and feet light tan; ventral surfaces of fore and hind feet naked with prominent carpal and palmar tubercles; front feet with four functional digits with claws, the first digit reduced to a rudimentary tubercle; hind feet with five functional digits with claws; tail noticeably short and distinctly bicolored dark brown above and buff below. Skull: Medium in size; compact and angular; zygomata heavy with a uniform lateral curvature; interorbital breadth markedly constricted; suprameatal portion of auditory bulla enclosed by processes of the supraoccipital and temporal bones; parietal ridges markedly reduced and inconspicuous; interparietal transversely elongated; nasals short and moderately flaring anteriorly; upper incisors markedly prognathous; dorsal margin of foramen magnum with prominent notch; audital portions of auditory bullae conspicuously inflated ventrally; pterygoid processes and external pterygoid fossae heavily fenestrated; hamulae large and applied to anteromedial portions of auditory bullae; molariform toothrows long and individual teeth with prominent inner and outer salient angles; anterior palatine foramina relatively short and narrow; posterior palatine canals small and inconspicuous.

Comparisons. Compared to representatives of *Microtus guentheri* Danford and Alston from the Valley of Ali Bey Dere, near Piringcikoy, 16 kilometers west of Istanbul, Turkey, the specimens from Libya differ strikingly in having markedly smaller, less angular skulls, narrower rostra, more ventrally inflated auditory bullae, more fragile zygomata, narrower basioccipitals, markedly smaller incisors, and the third molar nearly as large as the second, rather than being significantly smaller as in *guentheri*. In external characters, the specimens

from Libya are significantly larger, have less hair on the ears, are more brightly colored dorsally (Buckthorn Brown as opposed to Snuff Brown), have a greater suffusion of white ventrally, more orangish-buff on the dorsal surfaces of the fore and hind feet, and have more prominently bicolored tails.

In *M. mustersi* the tail is markedly longer than the hind foot and almost one fourth the length of the head and body, rather than only slightly larger than the hind foot and one-fifth the length of the head and body as in *M. guentheri*, and the sole of the hind foot is naked for a greater distance posterior to the base of the toes.

In the number of palmar and plantar pads and in the pattern and number of the molar prisms and reentrant angles, the Libyan specimens resemble *M. guentheri* and indicate relationship with the latter species.

Remarks. Hinton (1926) described *M. mustersi* as a species distinct from *Microtus philistinus* Thomas of Palestine. According to Hinton, *M. mustersi* is closely allied to *M. philistinus*, but differs in slightly darker (less grayish) dorsal color, slightly narrower choanae, slightly smaller auditory bullae, less reduction of the third molar posteriorly, and less salient temporal ridges with a wider interval between them. Hinton regarded these differences as somewhat tenuous but stated that "craniologically" the specimens representing both *M. mustersi* and *M. philistinus*, and upon which his comparisons are based, were all subadult and that fully adult specimens probably would show more marked differences.

Ellerman and Morrison-Scott (1951) regarded *M. mustersi* and *M. philistinus* as conspecific and relegated them both to subspecific rank under *M. guentheri*. Toschi (1954) also considered *M. mustersi* as a subspecies of *M. guentheri*. I agree with Ellerman and Toschi in regarding *M. mustersi* as a member of the "*M. guentheri*" group but feel that other morphological differences between the two are too great to suggest conspecificity, and here *M. mustersi* is regarded as a species distinct from *M. guentheri*.

Hinton's description of *Microtus mustersi* from Cyrenaica in 1926 constituted the first record of occurrence of a microtine rodent for the African continent, even though members of this group were widespread throughout Europe and Asia. The type series of *M. mustersi* obtained by Chaworth-Musters in 1926 from Barce, a specimen collected by H. W. Setzer in 1955 from 10 kilometers southwest of El Faidia, and the three specimens that I obtained from 5 kilometers west of Tocra are all from Cyrenaica and constitute the only known representatives of the subfamily Microtinae in Libya.

All specimens from Cyrenaica are either topotypes or near topotypes of *M. mustersi*. Those from the coastal plain near Tocra, however, are the farthest from the type locality, but two specimens are clearly immature and are unsuitable for comparative purposes. The third is of questionable adult status but is near or of comparable age to those specimens with which it is being compared from Merg (=Barce) and El Faidia. The specimen from Tocra is identical in color to *M. mustersi*. In cranial characters it resembles rather closely a topotype of *M. mustersi* from Barce but differs in slightly smaller size of skull and external dimensions, shorter and narrower anterior palatine foramina, slightly smaller pterygoid foramina, and slightly more inflated mastoidal portions of the auditory bullae.

From the specimen from near El Faidia, this specimen from near Tocra differs in the same characters as set forth above, except the two specimens are comparable in the length of the anterior palatine foramina.

These differences between the voles of the coastal plain and those from the higher slopes of the plateau are too slight to suggest subspecific differences and indicate that *M. mustersi* is a monotypic species whose range includes all of the Cyrenaican Plateau and the adjacent coastal plain wherever suitable habitat occurs.

Ecological observations. The three localities in Cyrenaica where voles are known to occur differ markedly in the character of the habitat. The type locality at Barce, according to Hinton (1926), is at an altitude of 300 meters and in a basin of interior drainage about 20 miles from the coast. *Microtus* inhabited open burrows with well marked "runs" in the cornfields. The ground was described as being "hard-baked." Near El Faidia, Setzer (1957) described the terrain as hilly and rocky, and a single specimen was obtained from the moist north-facing slope where mosses were growing. This locality is significantly higher in elevation than the Barce Valley and is near the highest point of the Cyrenaican Plateau. In contrast to the high valleys and mountain slopes near Barce and El Faidia, the site near Tocra is located on the lowest level of the coastal plain about one-half kilometer from the Mediterranean Sea. This particular portion of the coastal plain has a dense vegetative cover consisting primarily of interwoven patches of tamarix, large sedges, coarse grasses, and a species of bushlike woody perennial with purple flowers. All these plant-types form rather discrete communities composed almost exclusively of a single dominant type of plant. All voles were taken the same night from the dense understory of the bushlike perennials. Large series of *Mus musculus* and *Gerbillus campestris* and several specimens of *Crocidura russula* Hermann were also obtained from this

bushlike growth. The areas of tamarix, sedges, and grasses were trapped intensively, but yields were quite poor.

This portion of the coastal plain, with its lush and profuse vegetative cover, is not typical of most of the Cyrenaican coastal plain, and probably at these lower elevations voles are of very sporadic and local occurrence. The range of *M. mustersi*, in Libya, therefore probably is largely confined to the higher and more typically montane areas of the Cyrenaican Plateau and the Gebel Achdar, which provide more abundant and continuous habitat.

The occurrence of voles in Cyrenaica poses some very interesting zoogeographic problems, particularly since they are not known from coastal Egypt, the only conceivable dispersal route. It is possible that the population of voles in Cyrenaica are relicts from the period when the more boreal climates of the Pleistocene prevailed over North Africa. The Cyrenaican Plateau by virtue of its higher elevation has retained at least a vestige of these boreal elements, whereas the remainder of coastal Africa has become much drier and more sparsely vegetated and no longer contains habitats suitable for voles.

## Subfamily Gerbillinae

### Genus *Gerbillus* Desmarest

Lataste (1881, p. 506) divided the genus *Gerbillus* into two genera, *Gerbillus* and *Dipodillus* Lataste, and separated the latter from *Gerbillus* by the number of plantar pads, the pattern of infolding of enamel on the surfaces of the teeth, and by characteristics of the auditory bullae. According to Lataste, typical members of *Gerbillus* had one carpal pad and no plantar pads, while representatives of *Dipodillus* had five carpal and six plantar pads. Lataste used the character of naked feet to separate two species, *Gerbillus garamantis* Lataste and *Gerbillus hirtipes* Lataste. Heptner (1937) and Ellerman (1941) suppressed *Dipodillus* as a full genus. The latter author stated that members of the two genera could not be distinguished by cranial characters and that there was a lack of constancy in the characters used by Lataste to distinguish between the two genera. Later, Wassif (1956) and Setzer (1957) regarded *Dipodillus* as a subgenus of the older prevailing *Gerbillus* and used the presence or absence of hair on the hind feet to assign their specimens to the two subgenera. The present author uses this same character to separate the subgenera *Dipodillus* and *Gerbillus*, each represented in Libya by four species,

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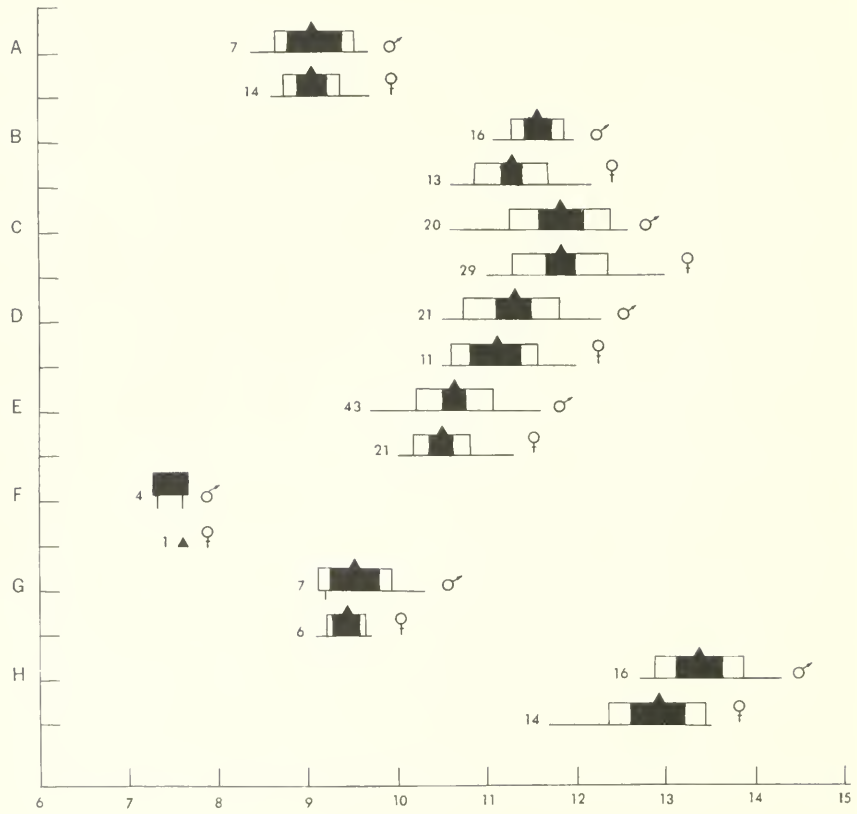


FIGURE 5.—Statistical comparison of length of nasals of the species of the genus *Gerbillus:* A, *G. amoenus:* B, *G. aureus;* C, *G. campestris;* D, *G. eatoni;* E, *G. gerbillus;* F, *G. henleyi;* G, *G. kaiseri;* H, *G. pyramidum.* For explanation of graphs see Plan of Treatment, p. 62.

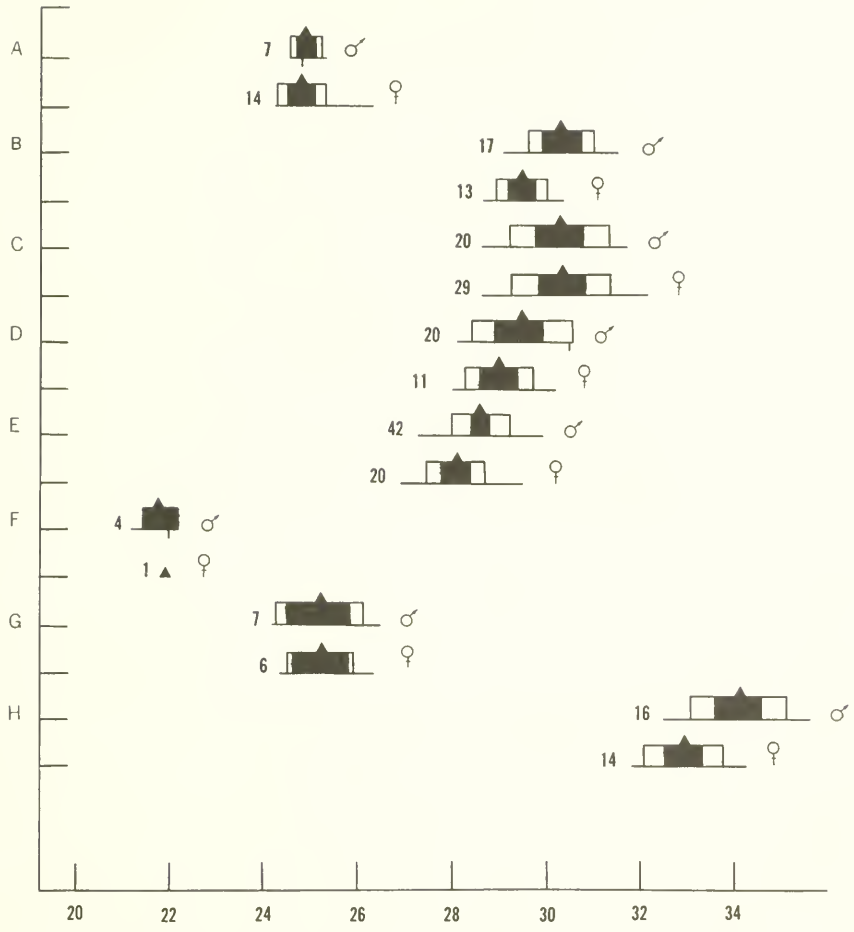


FIGURE 6.—Statistical comparison of occipitonasal length of the species of *Gerbillus*. Notation remains the same as in figure 5.

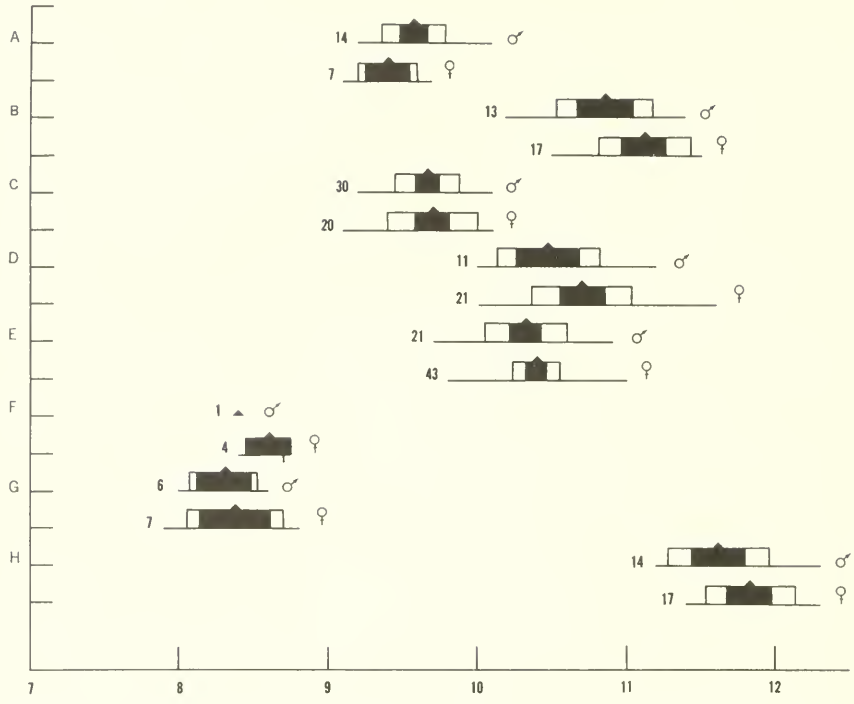


FIGURE 7.—Statistical comparison of length of auditory bulla of the species of *Gerbillus*. Notation remains the same as in figure 5.

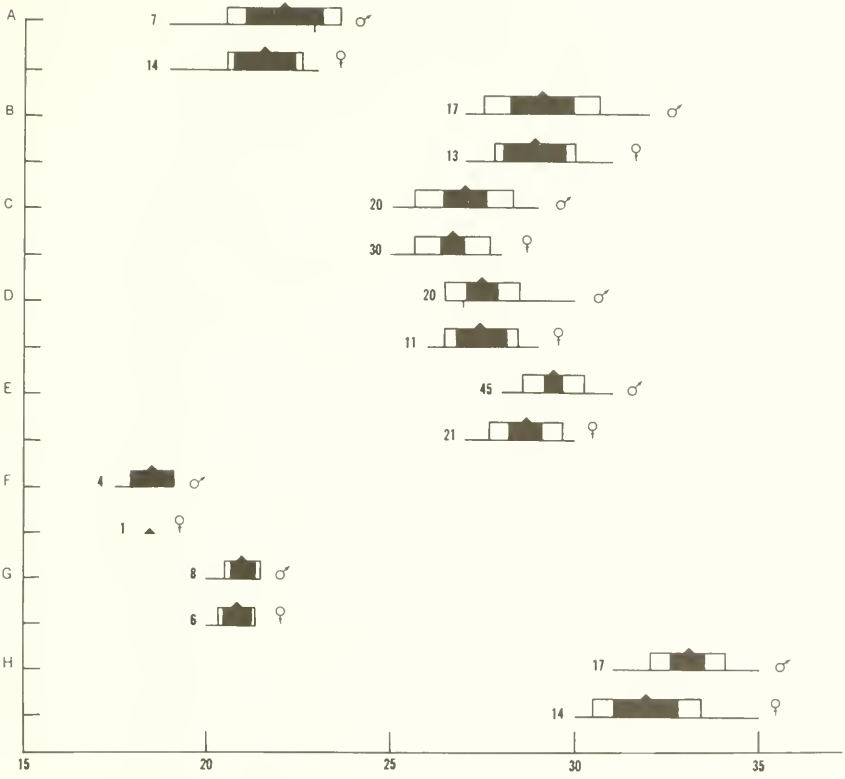


FIGURE 8.—Statistical comparison of length of hind foot of the species of *Gerbillus*. Notation remains the same as in figure 5.

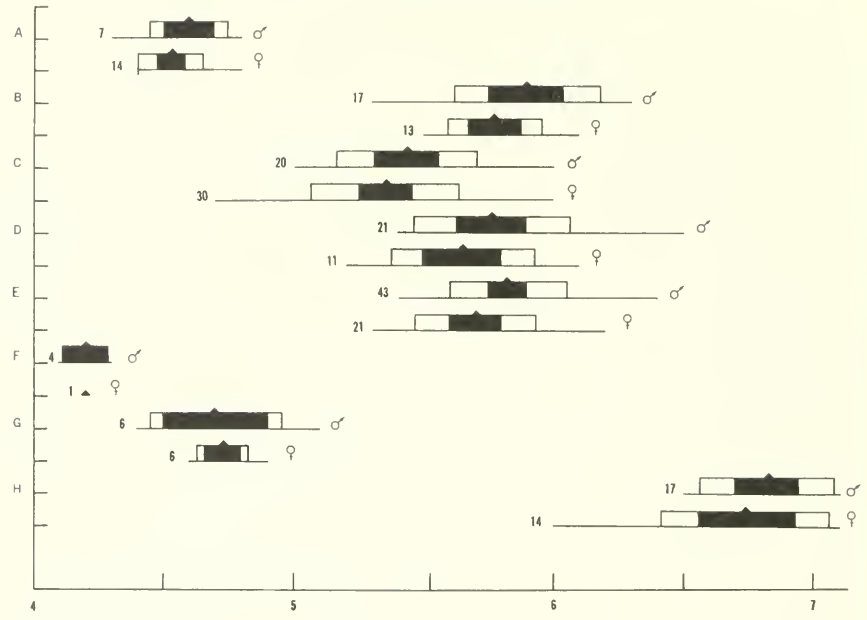


FIGURE 9.—Statistical comparison of least interorbital breadth of the species of *Gerbillus*. Notation remains the same as in figure 5.

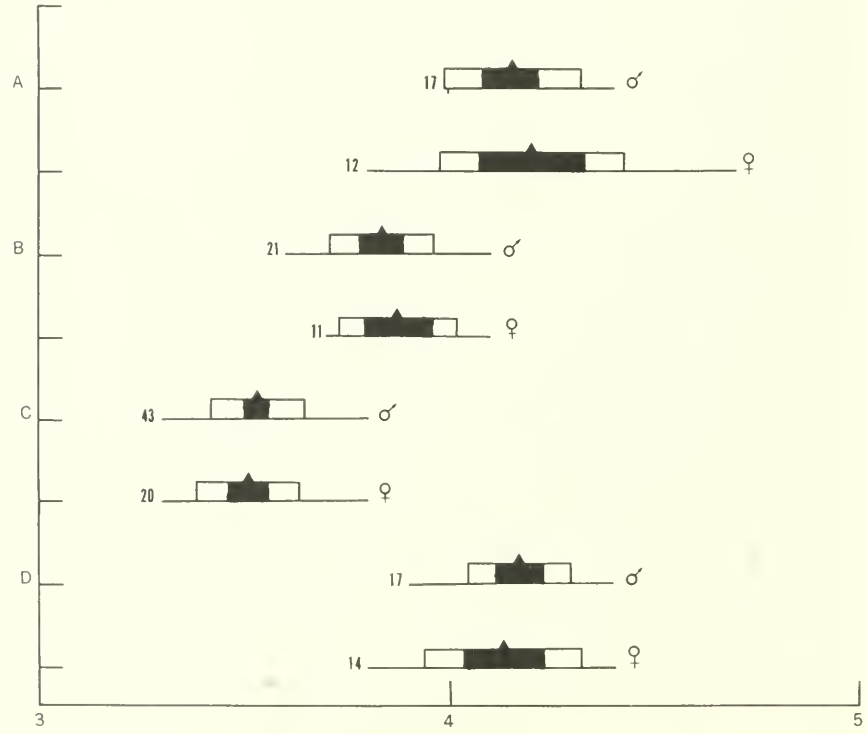


FIGURE 10.—Statistical comparison of upper molariform toothrow of the species of the subgenus *Gerbillus:* A, *G. aureus;* B, *G. eatoni;* C, *G. gerbillus;* D, *G. pyramidum.*

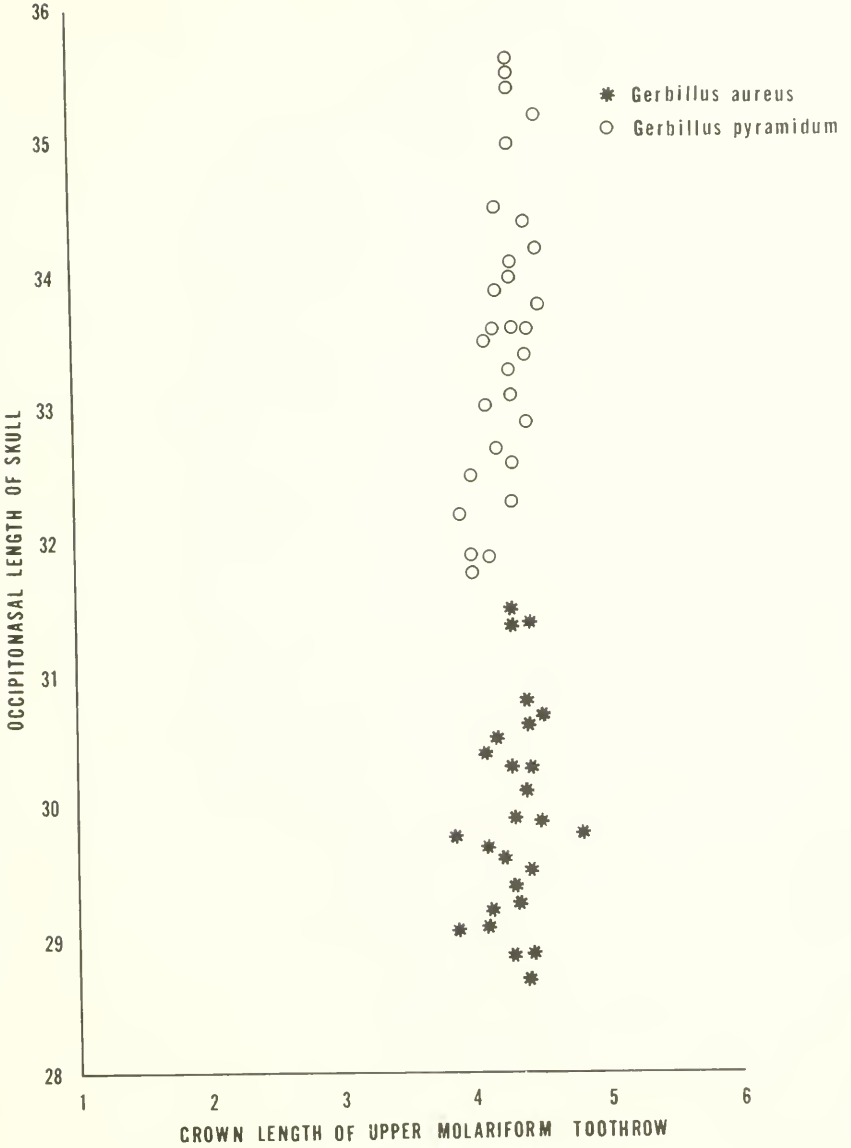


FIGURE 11.—Comparison of crown length of upper molariform toothrow relative to occipitonasal length of *Gebillus aureus* and *Gerbillus pyramidum*.

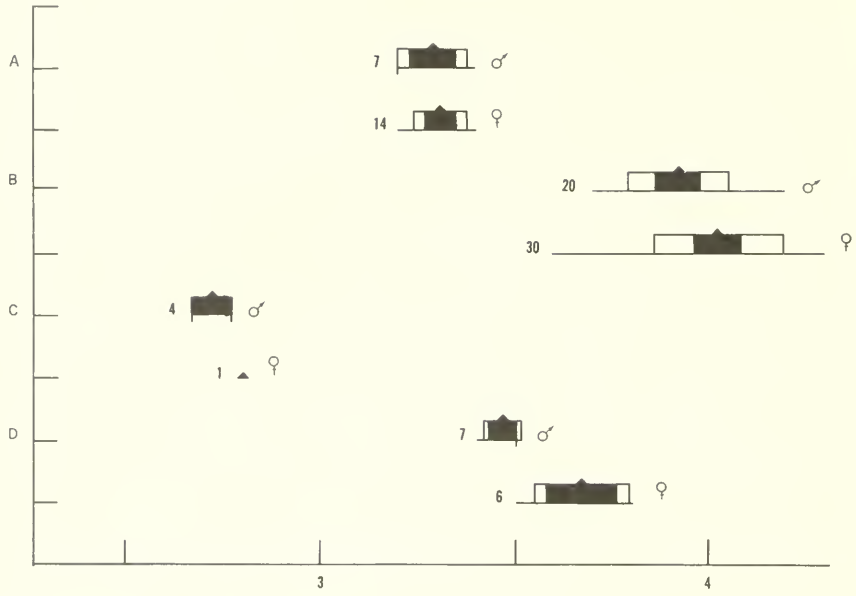


FIGURE 12.—Statistical comparison of crown length of upper molariform toothrow of the species of the subgenus *Dipodillus:* A, *Gerbillus amoenus;* B, *G. campestris;* C, *G. henleyi;* D, *G. kaiseri.*

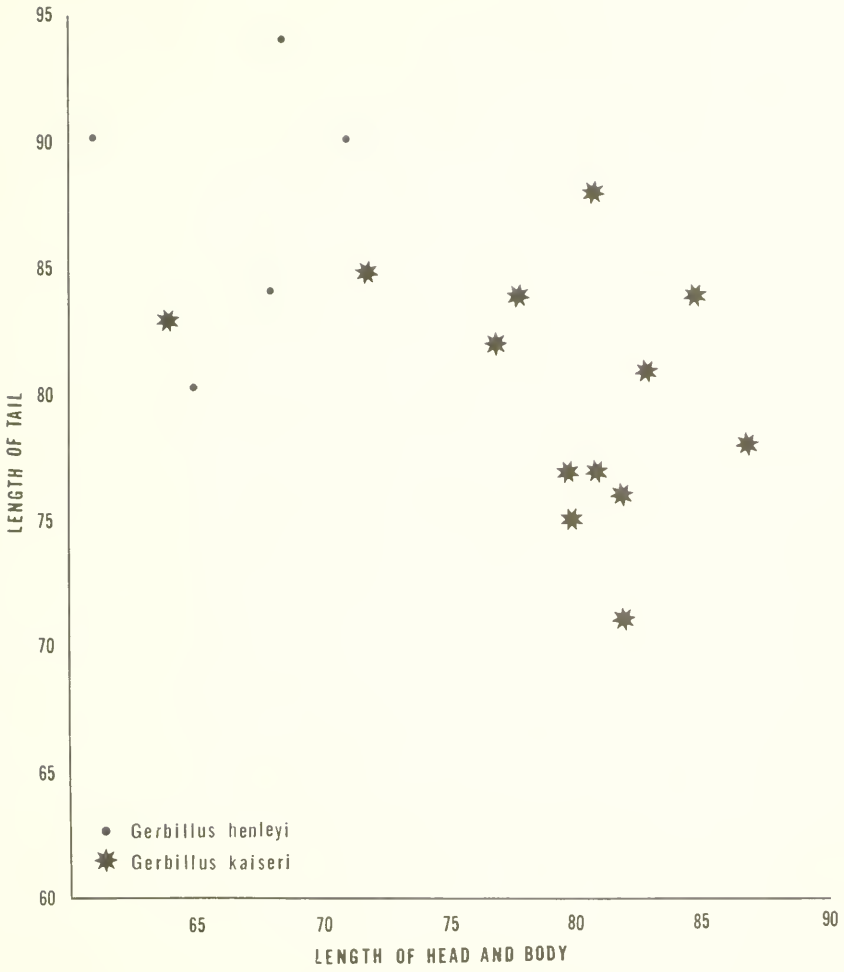


FIGURE 13.—Comparison of length of tail relative to length of head and body of *Gerbillus henleyi* and *Gerbillus kaiseri*.

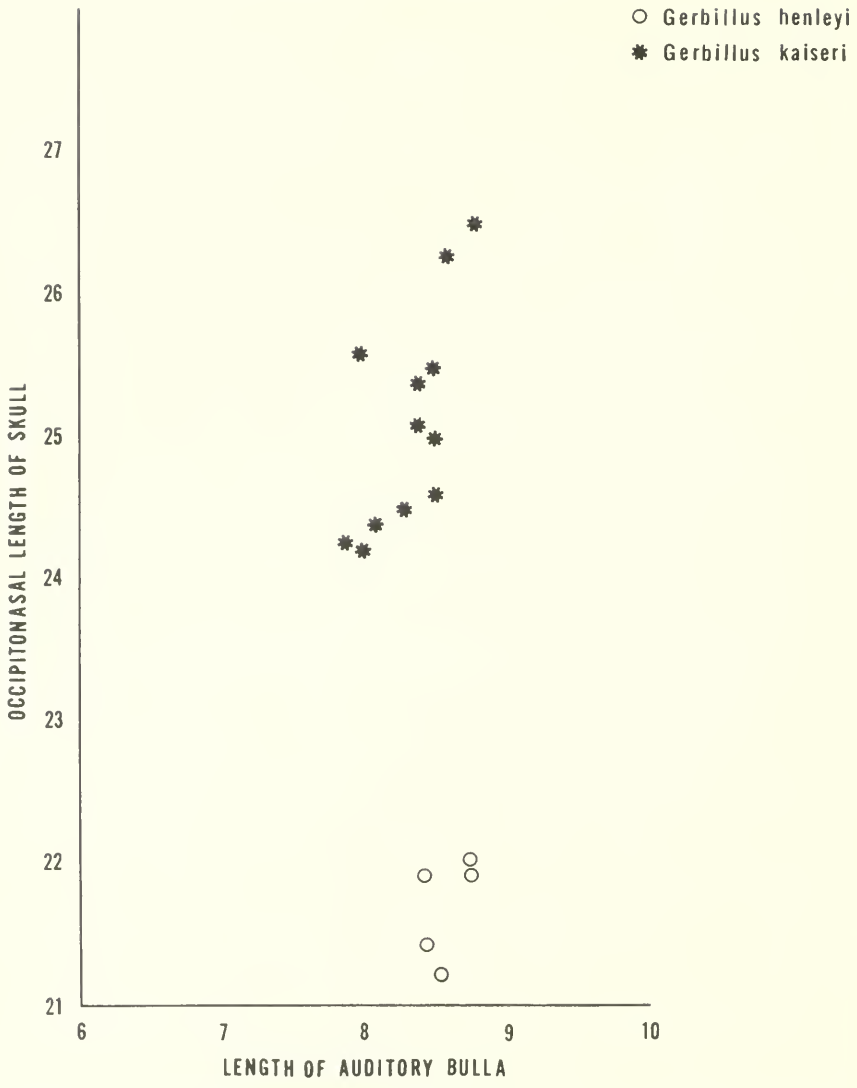


FIGURE 14.— Comparison of length of auditory bulla relative to occipitonasal length of *Gerbillus henleyi* and *Gerbillus kaiseri*.

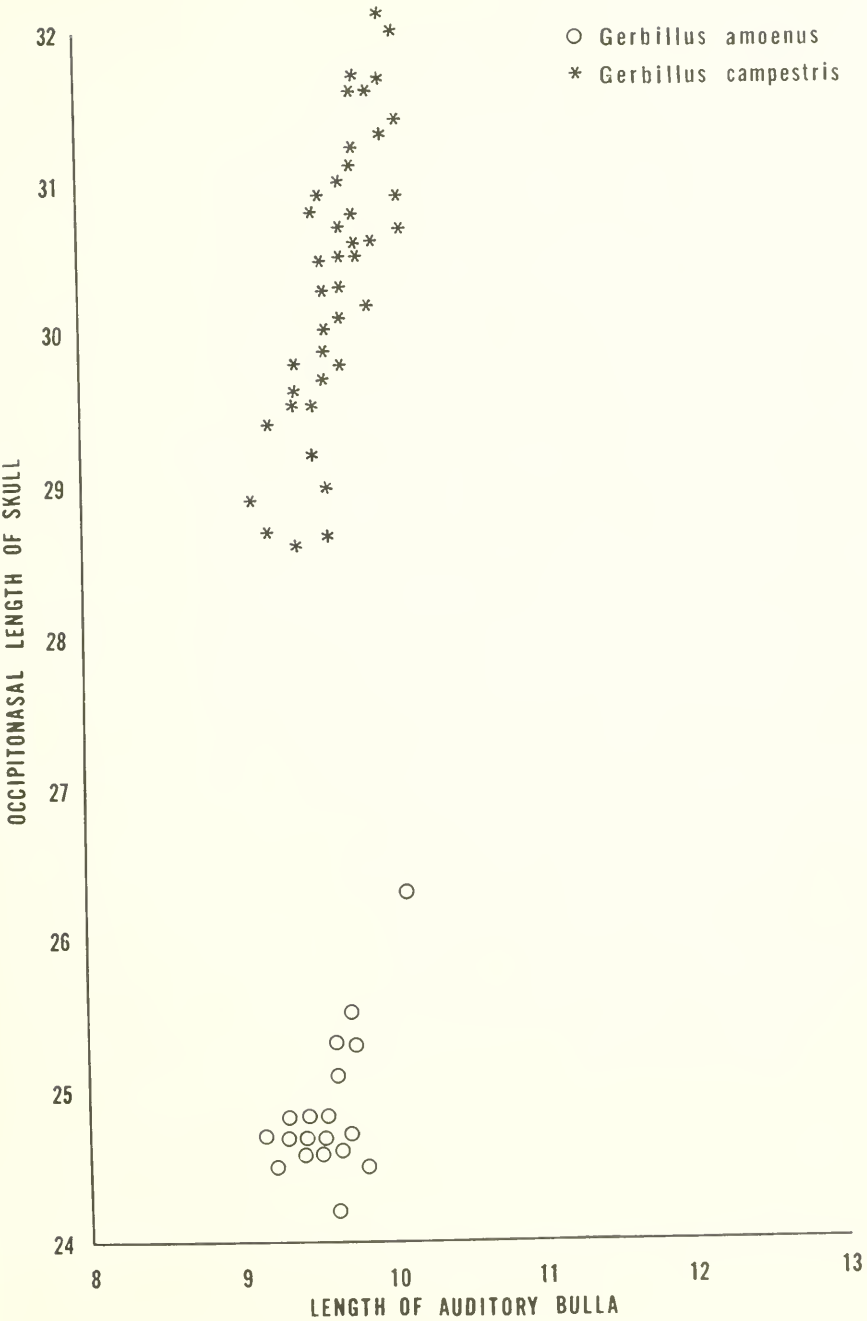


FIGURE 15.—Comparison of length of auditory bulla relative to occipitonasal length of *Gerbillus amoenus* and *Gerbillus campestris*.

the former consisting of *G. amoenus, G. campestris, G. henleyi,* and *G. kaiseri* and the latter composed of *G. aureus, G. eatoni, G. gerbillus,* and *G. pyramidum.*

Without doubt, gerbils are the most variable morphologically and the most ecologically tolerant of all the Libyan rodents. They have adapted to practically every available environmental situation. The ability of these gerbils to exploit such a wide array of ecological opportunities indicates a broad genetic constitution. This marked adaptability has enabled them to occupy a vast geographic range in Libya and has contributed to the maintenance of a common morphological pattern among the widely scattered populations.

Owing to the broad genetic constitution of the species of the genus *Gerbillus,* there is wide variation in color and in cranial and external characters of the component subspecies. Individual subspecies vary markedly in any given character and generally are distinguished from each other by an aggregate of characters rather than by specific, measurable cranial differences. In gerbils, the usual criteria for recognizing subspecies, such as differences in color and cranial and external dimensions, are employed, but these differences are usually much more subtle than in other genera of Libyan rodents.

Owing to this genetic plasticity in gerbils, the usual 84 to 93 percent rule (1 to 1.5 standard deviations on either side of the mean) for separating the members of two subspecies by a given character is seldom realized, and the percentage of overlap in a character is usually far greater.

The ranges of many of the subspecies of gerbils in Libya are contiguous, and gene exchange is of common occurrence. These intergrading populations contain genes from both subspecies and contribute significantly to the maintenance of genetic variability among the populations of gerbils in Libya.

In most populations of a given species, and particularly in those subspecies which are geographic isolates, genetic fixation occurs rapidly and trends develop toward morphological distinctness.

### Key to the Subgenera of Gerbillus

Plantar surfaces of hind feet hairy ..... **Gerbillus**
Plantar surfaces of hind feet naked ..... **Dipodillus**

### Key to the Species of the Subgenus Gerbillus

1. Skull prominently domed; anterior palatine foramina markedly enlarged. **G. eatoni**
   Skull not prominently domed; anterior palatine foramina not markedly enlarged ..... 2
2. Occipitonasal length of skull less than 30 mm; length of upper molariform toothrow less than 4 mm ..... **G. gerbillus**
   Occipitonasal length of skull usually more than 30 mm; length of molariform toothrow usually more than 4 mm ..... 3
3. Tail with distinct brush; the latter never black ..... **G. pyramidum**
   Tail without distinct brush; the latter frequently black ..... **G. aureus**

#### *Gerbillus aureus* Setzer

*Gerbillus pyramidum aureus* Setzer, Proc. Biol. Soc. Wash., vol. 69, pp. 179–180, Dec. 31, 1956 (12 km W Zliten, Tripolitania Province, Libya).

General distribution of species. Libya; range probably also includes coastal areas of Tunisia.

Distribution in Libya. Coastal plain and littoral deserts of northern Tripolitania.

Distribution of the subspecies in Libya.

*Gerbillus aureus aureus.* Tripolitania: Gebel Nefusa and the coastal plain between Azizia and the Gulf of Sirte.

*Gerbillus aureus favillus.* Tripolitania: Vicinity of Sirte; range probably includes much of the coastal plain of the Gulf of Sirte.

*Gerbillus aureus nalutensis.* Tripolitania: Coastal plain of extreme northwestern Tripolitania.

Comparisons. This species can be distinguished from *Gerbillus pyramidum,* which it most closely resembles, by its markedly smaller skull, smaller body, shorter, less tufted tail, generally darker color, shorter and wider posterior palatine canals, wider anterior palatine foramina, and longer molariform toothrows relative to occipitonasal length.

From *Gerbillus gerbillus, G. aureus* differs in larger body and skull, larger molariform teeth, markedly less tufted tail, larger anterior palatine foramina, more robust skull, heavier zygomata, and generally darker, less orangish dorsal color.

*Gerbillus aureus* can be readily separated from *Gerbillus eatoni* by its larger body, larger and heavier skull, larger molariform teeth, smaller anterior palatine foramina, longer posterior palatine canals, smaller and less inflated auditory bullae, and markedly more flattened braincase.

Remarks. Setzer described *Gerbillus pyramidum aureus* (=*Gerbillus aureus aureus*) (1956, p. 179) and *Gerbillus pyramidum favillus* (=*Gerbillus aureus favillus*) (1956, p. 180) as new subspecies of *G. pyramidum.* In naming these new subspecies, he had only topotypical

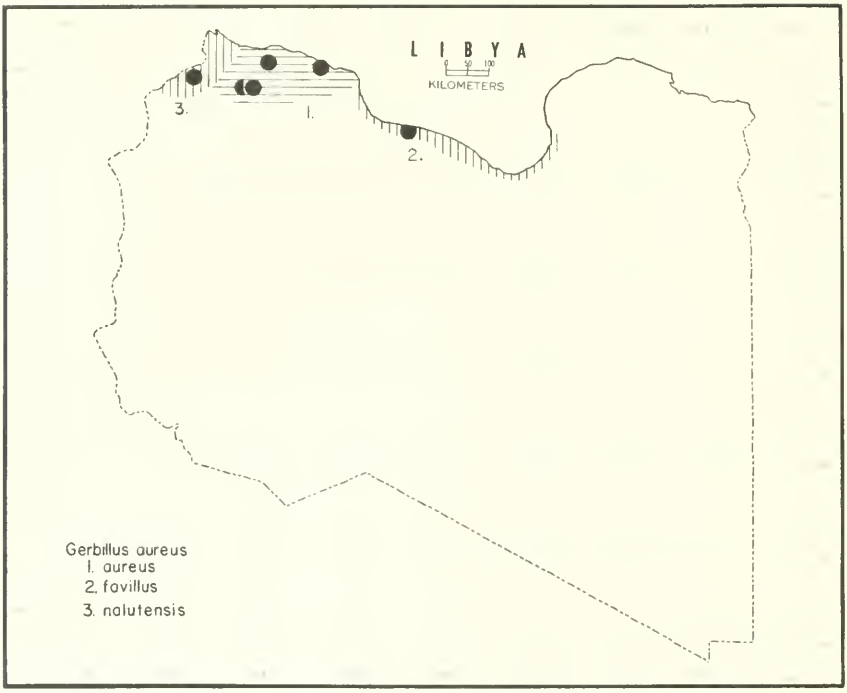


FIGURE 16.—Distribution of the subspecies of *Gerbillus aureus*.

specimens. In the present study specimens are available from more localities and the systematic position of these gerbils can be more accurately determined. It is now known that these subspecies actually represent populations of a new species (*Gerbillus aureus*) which can be distinguished readily from *G. pyramidum* by its smaller size, conspicuously less tufted tail, and darker dorsal color. The name *aureus*, because of page priority, is elevated to specific rank and *favillus* becomes a subspecies of the new species thus formed. In addition, a new subspecies, *Gerbillus aureus nalutensis*, is being described from northwestern Tripolitania. The validity of this species (*G. aureus*) is further strengthened by the absence of any intergradation with *G. pyramidum*. Setzer (1956) also recognized no intergrades between *aureus* and *favillus* and gerbils representing *G. pyramidum tarabuli*, whose range is to the south.

This new species is the only species of gerbil known to inhabit northwestern Tripolitania. The nearest populations of *Gerbillus gerbillus* and *G. pyramidum* occur much farther south in the northern confines of the Hamada el Hamra. To the east, in the vicinity of Sirte, *G. aureus favillus* occurs sympatrically with *G. pyramidum* and *G. eatoni*.

In color and overall body size, members of *G. aureus* from Libya closely resemble representatives of *Gerbillus pyramidum hirtipes* Lataste from Ain Sefra, southwestern Algeria, but differ from the latter in having noticeably longer tails. Cranially, the two groups are of comparable size, but can be distinguished by the more massive, compact skulls, heavier zygomata, and wider rostra of the Algerian specimens. Ellerman and Morrison-Scott (1951), in keeping with their objective of simplifying nomenclature, relegated Lataste's *Gerbillus hirtipes* (1882) to subspecific status under the more widely distributed *Gerbillus pyramidum*. At this time Tripolitania and the coastal areas of western Libya were not represented by specimens, and *Gerbillus aureus* was unknown. In the majority of external and cranial characters these specimens from Algeria are much closer to *G. aureus* than to *G. pyramidum;* in fact, they bear little resemblance to the latter. When more localities in Algeria are represented by specimens of *G. aureus* and *G. pyramidum* and when topotypes of *G. p. hirtipes* are available for comparison, the latter will probably be reinstated as a full species, distinct from either *G. aureus* or *G. pyramidum* but more closely related to the former, or *aureus* and *hirtipes* may be regarded as conspecific, in which case the older *hirtipes* will take precedence.

Ecological observations. Vegetated dunes are apparently the preferred habitat of this gerbil, but they occur also in the littoral deserts where dunes are usually lacking. In the Gebel Nefusa, the habitat consists of rolling uplands with rather dense vegetative cover, and sand, if present, is usually localized.

### *Gerbillus aureus aureus* Setzer

*Gerbillus pyramidum aureus* Setzer, Proc. Biol. Soc. Wash., vol. 69, pp. 179–180, Dec. 31, 1956 (12 km W Zliten, Tripolitania Province, Libya).

Specimens examined. Forty, from Tripolitania: 12 km W Zliten, 12; 25 km N Gharian, 8; 20 km E Rumia, 8 (1 skin only); 3 km E Rumia, 10; 12 km S Chicla, 2.

Measurements. Averages and extremes of six adult males and measurements of two adult females, 302073 and 302075, from the type locality, are: Total length 236.8 (223–244), 222, 230; length of tail 131.8 (127–137), 125, 129; length of hind foot 30.7 (30–31), 30, 30; length of ear 15.2 (13–18), 13, 13; occipitonasal length of skull 30.7 (29.9–31.6), 29.2, 30; length of auditory bulla 11.1 (10.9–11.2), 10.7, 10.9; crown length of upper molariform toothrow 4.1 (4–4.3), 4.1, 4.1; greatest breadth across zygomatic arches 16 (15.6–16.5), 15.6, 15.9; least interorbital breadth 5.7 (5.5–6), 5.4, 5.4; breadth of rostrum at level of antorbital foramina 3 (2.9–3.1), 2.8, 2.9; greatest length of nasals 11.7 (11.4–11.9), 11, 11.5.

Diagnosis. Members of this subspecies show pronounced variation in dorsal color, which ranges from uniform, brilliant Ochraceous-Buff in some specimens to more subdued Tawny-Olive in others. This darker color results from a strong admixture of dark-tipped hairs. These darker specimens are characterized as follows: Mystacial, rostral, and circumoral areas and supraorbital patch Light Buff; postauricular region Clay Color heavily suffused with black; eye ring black; pinna of ear dark distally (Hair Brown) with fringe of buff-colored hairs on anterior margin; anteromedial surface of pinna Cinnamon-Buff; vibrissae short, with occasional dark hairs; lateral surface of forearm with buffy patch; fore and hind feet and legs densely haired dorsally and ventrally and each bearing five digits with claws; tail relatively long and indistinctly bicolored Cinnamon-Buff dorsally and Light Ochraceous-Buff ventrally, becoming more subdued distally and appearing Light Ochraceous-Buff; terminal pencil relatively reduced and Hair Brown; entire underparts white. The lighter, more brilliantly colored specimens have white rostral, mystacial, and circumoral areas, much lighter vibrissae, more distinct postauricular patches, a smaller supraorbital patch, more conspicuously bicolored tails, and lack the buffy patch on the forearm. Skull: Medium in size, somewhat gracile and narrow in dorsal aspect; upper molariform toothrow relatively short and individual teeth small; anterior palatine foramina large; auditory bullae small and ventrally inflated; zygomatic arches almost parallel to orbital surface.

Comparisons. From the type series of *Gerbillus aureus favillus*, *Gerbillus aureus aureus* differs in larger size and larger cranial measurements, being comparable in crown length of upper molariform toothrow, least interorbital breadth and breadth of rostrum at level of antorbital foramina. In color, *G. a. aureus* is darker and more varied in dorsal color and has a markedly more distinct and darker penicillate tail. Members of the nominate subspecies have more parallel toothrows, more ventrally inflated auditory bullae, relatively longer posterior palatine canals, and the zygomatic arches are parallel rather than bowed medially. Setzer (1956) used most of the foregoing characters to separate these two subspecies but stated that the skulls of animals of these two subspecies were of comparable size. The present study, however, shows that representatives of *G. a. aureus* are significantly larger in almost all cranial measurements.

For comparison with *Gerbillus aureus nalutensis*, see account of that subspecies.

Remarks. This subspecies apparently represents a genetically heterogeneous group, and the component populations represent a rather broad assemblage of morphological patterns. Specimens from the vicinity of Rumia are slightly darker than those from the type

locality and have lighter colored, less prominent tufts on the tail. The common "golden" color phase is also apparently not present in these gerbils from Rumia. In contrast, the series from 25 kilometers north of Gharian consists almost exclusively of gerbils having this "golden" color. Animals from near Gharian also are wider across the zygomatic arches and have larger molariform teeth. In the aggregate, however, many morphological characters are common to all these different populations and serve to unite them into a single subspecies.

Setzer (1957) assigned a single specimen (no. 302102) from 5 kilometers west of El Agheila, Cyrenaica Province, to *Gerbillus pyramidum aureus* (=*Gerbillus aureus aureus*). This specimen resembles *Gerbillus aureus* in color and general size but in the prominent tufted tail and all other cranial and external characters, it is typical of *Gerbillus pyramidum* to which it is here referred.

Ecological observations. The specimens from near Rumia and Chicla were taken near the brink of the coastal escarpment. The habitat here consists of gently rolling valleys and depressions with rather dense vegetative cover consisting of a wide assemblage of close-growing perennial and annual species. The ground in this area is quite rocky, and the soil has a clay or sandy base. Shallow deposits of smooth sand and small dunes are present, but these are of rare occurrence. The collecting site north of Gharian is located on the coastal plain where large, permanently vegetated dunes are present. I have not visited the type locality near Zliten, but presumably the habitat resembles that near Gharian.

### *Gerbillus aureus favillus* Setzer

*Gerbillus pyramidum favillus* Setzer, Proc. Biol. Soc. Wash., vol. 69, pp. 179–180, Dec. 31, 1956 (2 km E Sirte, Tripolitania Province, Libya).

Specimens examined. Twenty, from Tripolitania: 5 km E Sirte, 8; 2 km E Sirte, 12.

Measurements. Averages and extremes of 7 males and 13 females from the above localities are, respectively: Total length 226.1 (216–240), 220.1 (210–236); length of tail 125.7 (119–135); 119.3 (110–132); length of hind foot 30.4 (30–31), 30.3 (30–31); length of ear 14.4 (13–15), 13.6 (13–15); occipitonasal length of skull 29.7 (29.3–30.5), 29.4 (28.4–30.1); length of auditory bulla 10.5 (10.3–10.8), 10.5 (10.3–10.9); crown length of upper molariform toothrow 4.1 (4.1–4.2), 4.2 (4–4.3); greatest breadth across zygomatic arches 15.5 (15.1–16.6), 15.7 (15.2–16.3); least interorbital breadth 5.8 (5.5–6), 6 (5.7–6.2); breadth of rostrum at level of antorbital foramina 3.2 (3–3.3), 3.2 (3.1–3.4); greatest length of nasals 11.4 (11–12), 11.3 (10.4–13.1).

Diagnosis. Upperparts uniformly Clay Color becoming paler on sides and with admixture of brownish hairs on back; postauricular

patches conspicuous and white; supraorbital patch white; mystacial, circumoral and pectoral areas, forelegs, hindlegs, feet, and entire underparts pure white; pinna of ear sparsely haired, darker colored distally, Cinnamon-Buff on anteromedial surface, and bearing a row of fine buffy hairs on anterior margin; vibrissae short and composed almost entirely of white hairs; fore and hind feet bearing five digits with claws; tail relatively short, distinctly bicolored Cinnamon-Buff dorsally, Pale Pinkish Buff ventrally, and with faint terminal Avellaneous pencil. Skull: Relatively small, gracile, and flattened in profile; anterior palatine foramina relatively wide; upper molariform toothrows bowed slightly laterally, relatively short, and individual teeth small; auditory bullae relatively small; zygomatic arches bowed slightly medially.

For comparisons with *G. a. aureus* and *G. a. nalutensis*, see accounts of those subspecies.

Remarks. This subspecies is known only from the coastal plain in the vicinity of Sirte on the western shores of the Gulf of Sirte, but its range probably includes a much greater area to the east. I was unable to obtain additional specimens of this subspecies and, consequently, obtained no firsthand data regarding their habitat preferences. Setzer (1956, p. 181) describes the habitat at the type locality as consisting of "loose coastal dunes where the vegetation had been heavily eaten by domestic animals." The pale dorsal color of these gerbils may result from a genetic response to the color of these sandy areas.

One specimen, no. 302096, from 5 kilometers east of Sirte has large molariform teeth and anterior palatine foramina, a flattened braincase, and is pallid in dorsal color. These characters are typical of *G. a. favillus*, and this specimen is referred to that subspecies. This same specimen, however, in size of body, external measurements, and the small size of the skull closely resembles animals belonging to *Gerbillus gerbillus*. This parallelism probably does not indicate a direct relationship with *G. gerbillus* but more likely is the result of a response to similar environmental conditions or represents an extreme in the range of variation for the subspecies *G. a. favillus*.

#### *Gerbillus aureus nalutensis*, new subspecies

Holotype. Adult male, skin and skull, USNM 321816, from 40 km ENE Nalut, Tripolitania Province, Libya; obtained Nov. 12, 1961, by H. W. Setzer, original no. 3113.

Specimens examined. Forty, all from the type locality.

Diagnosis. Upperparts Tawny-Olive with strong suffusion of blackish hairs in interauricular and subauricular regions and on rump; sides and flanks paler than dorsum; eye ring black; postauricular and

supraorbital patches white; mystacial, rostral, circumoral, and pectoral areas white, the latter tinged with buff; vibrissae short and with numerous dark hairs; pinna of ear drab-colored distally, basally approaching color of dorsum and with row of buffy hairs on anterior margin; fore and hind feet densely haired, white, and with five digits bearing claws; entire underparts pure white; tail Cinnamon-Buff with admixture of brownish hairs dorsally, grading to Pinkish Buff ventrally and terminating in a distinct blackish-brown pencil. Skull: Relatively large and robust, auditory bullae large and bulbous; molariform toothrows long, individual teeth large; rostrum wide; braincase wide and flat.

Measurements. Averages and extremes of 17 adult males and 13 adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 231.2 (218–249), 224 (213–238), [234]; length of tail 130.4 (117–142), 125.6 (106–132), [130]; length of hind foot 29.2 (27–31), 28.8 (27–31), [30]; length of ear 14.9 (14–16), 14.3 (13–15), [15]; occipitonasal length of skull 30.3 (29.1–31.5), 29.5 (28.7–30.3), [30.7]; length of auditory bulla 11.1 (10.5–11.5), 10.9 (10.2–11.4), [11.3]; crown length of upper molariform toothrow 4.3 (3.9–4.5), 4.3 (3.9–4.4), [4.5]; greatest breadth across zygomatic arches 16.2 (15.7–17.1), 15.6 (15.1–16.1), [16.3]; least interorbital breadth 5.9 (5.3–6.3), 5.8 (5.5–6.1), [6]; breadth of rostrum at level of antorbital foramina 3.3 (2.9–3.4), 3.1 (3–3.4), [3.4]; greatest length of nasals 11.6 (11.1–12.2), 11.3 (10.6–11.6), [11.8].

Comparisons. From topotypes of *Gerbillus aureus aureus*, the type and paratypes of *G. a. nalutensis* differ in having more robust skulls, markedly larger and wider auditory bullae, markedly longer molariform toothrows, larger individual molariform teeth, wider braincases, and wider and shorter rostra. In color, *G. a. nalutensis* is somewhat darker dorsally with more suffusion of black hairs on the rump, and the tail has a darker colored pencil.

This new subspecies can be distinguished from *Gerbillus aureus favillus* by darker dorsal color, darker (almost black) pencil, markedly longer molariform toothrows, larger size of individual teeth, much larger, more bulbous auditory bullae, more domed braincase, wider rostrum, and markedly larger size of body and cranium.

Remarks. Although a fundamental morphological pattern is always present in members of this subspecies, they vary considerably in color and cranial characters. As in the other two subspecies of *G. aureus*, dorsal color ranges from the typical dark form, with a heavy suffusion of black, to the more uniformly colored "golden" form. Specimens showing all gradations in intermediate color are also known. Cranially, this subspecies is remarkably polymorphic, partic-

ularly as concerns the size and shape of the auditory bullae, the relative length and width of the anterior palatine foramina, the degree of arching of the braincase, the length of the molariform toothrow, and the size of the individual molariform teeth. This polymorphism suggests the presence of sibling species within this population from Nalut, but overlap of characters occurs too frequently, and no specific combinations of characters are demonstrable for individual specimens. Apparently this population from Nalut represents one of pronounced genetic fluidity which has engendered this wide array of morphological patterns.

Although this new subspecies is known from only the type locality, its range doubtless includes the coastal plain and littoral deserts of southern Tunisia and, in Libya, probably extends much farther along the coastal plain to the east. In Libya, there are no apparent barriers to dispersal along the coastal plain, and intergradation between animals of *G. a. nalutensis* and those of the nominate subspecies takes place probably somewhere between Tripoli and Nalut.

Ecological observations. The type locality consists of a series of vegetated dunes. These dunes are not extensive and occur sporadically as irregular bands along the coastal plain near the coastal escarpment. The role of the coastal escarpment in retarding the velocity of the winds probably has resulted in the formation of these coastal dunes.

Forty-seven gerbils and five jirds were obtained from a single night of trapping at 40 kilometers east-northeast of Nalut. The presence of numerous active burrows plus this large catch suggests a high population density of rodents. A severe wind storm or "ghibli"

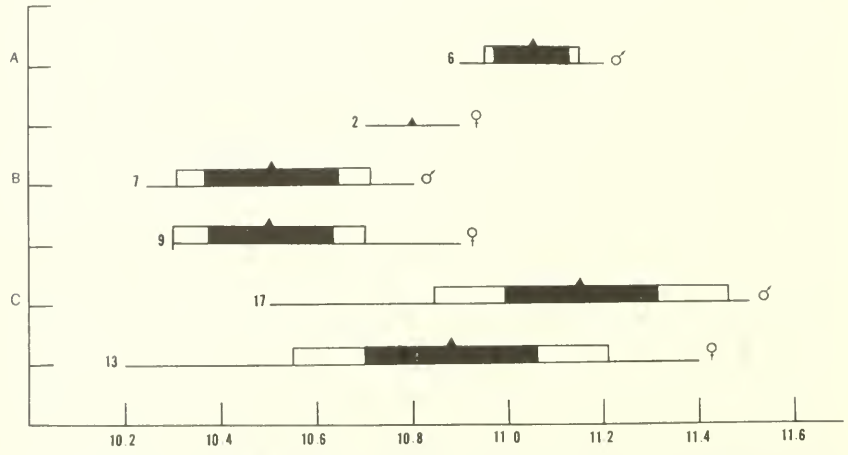


Figure 17.—Statistical comparison of length of auditory bulla of the subspecies of *Gerbillus aureus:* A, *G. a. aureus;* B, *G. a. favillus;* C, *G. a. nalutensis.*

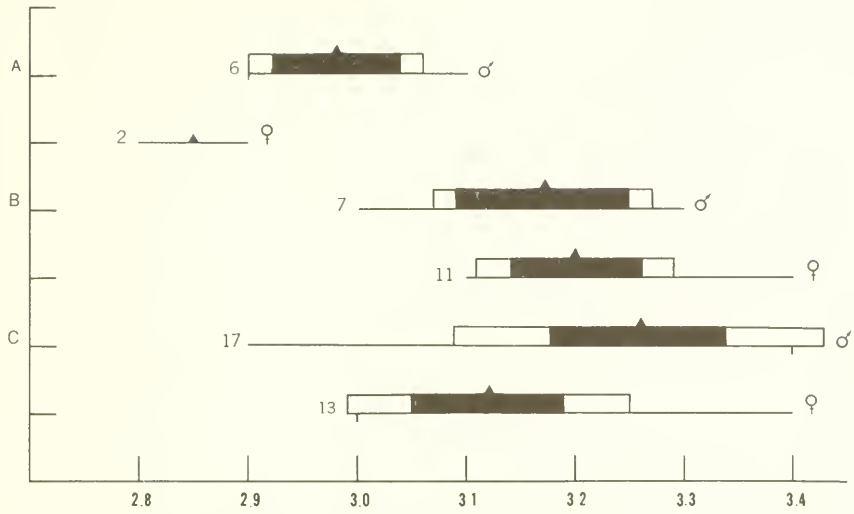


FIGURE 18.—Statistical comparison of breadth of rostrum of the subspecies of *Gerbillus aureus*. Notation remains the same as in figure 17.

developed during the night but had little apparent effect on trapping success.

The name *nalutensis* is used in reference to the village of Nalut on the westernmost limits of the Gebel Nefusa and located a short distance from the type locality.

### *Gerbillus eatoni Thomas*

*Gerbillus eatoni* Thomas, Proc. Zool. Soc. London, vol. 2, pt. 1, p. 6, October 1902 (El Cusher, Tripolitania Province, Libya).

GENERAL DISTRIBUTION OF SPECIES. Libya; range probably also includes coastal areas of northern Algeria, Tunisia, and Egypt.

DISTRIBUTION IN LIBYA. Coastal areas of Tripolitania and Cyrenaica.

DISTRIBUTION OF THE SUBSPECIES IN LIBYA.

*Gerbillus eatoni eatoni*. CYRENAICA: Coastal plain and littoral deserts in vicinity of Agedabia and north to Gheminez; TRIPOLITANIA: Coastal plain of the Gulf of Sirte, probably including the coastal areas to the west.

*Gerbillus eatoni inflatus*. CYRENAICA: Coastal plain and littoral deserts north and east of the Cyrenaican Plateau.

*Gerbillus eatoni versicolor*. CYRENAICA: Coastal plain of Cyrenaica in vicinity of Benghazi.

PUBLISHED RECORDS IN LIBYA. CYRENAICA: Vicinity of Benghazi (Klaptocz, 1909); TRIPOLITANIA: Wadi Agarib, Wadi Aggar, El

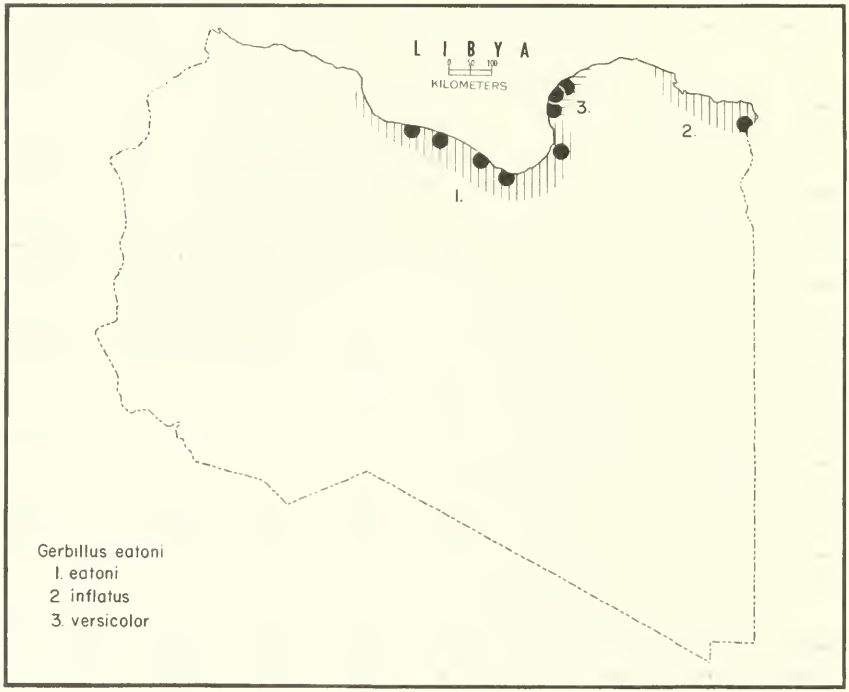


FIGURE 19.— Distribution of the subspecies of *Gerbillus eatoni*.

Cusher (Thomas, 1902); vicinity of Gharian and Tripoli (Klaptocz, 1909).

COMPARISONS. This species most nearly resembles *Gerbillus gerbillus* but can be distinguished by its darker color, less tufted tail, markedly larger and more inflated auditory bullae, conspicuously domed braincase, larger anterior palatine foramina, and shorter and wider posterior palatine canals.

From *Gerbillus aureus* and *Gerbillus pyramidum*, *G. eatoni* differs in its markedly smaller overall size, relatively larger and more inflated auditory bullae, smaller molariform teeth, and more domed braincase.

REMARKS. Thomas (1902) described *Gerbillus eatoni* as a full species on the basis of its conspicuously domed and bulbous braincase and rather large auditory bullae. He further stated that this gerbil was related to *Gerbillus andersoni* (=*Gerbillus gerbillus andersoni* de Winton), but the two species were separable by the larger and more bulbous braincase of *G. eatoni*. Later, Ellerman and Morrison-Scott (1951) placed *G. eatoni* in synonymy under *Gerbillus gerbillus gerbillus*. This erroneous assignment probably was based on too few specimens, although they listed specimens of this gerbil from

three localities in northern Tripolitania. Setzer (1957) recognized *G. eatoni* as a full species largely on the characters established by Thomas. He collected both species from 5 kilometers west of El Agheila, and in the present study, *G. gerbillus* and *G. eatoni* were found to occur together at several localities in coastal Tripolitania and Cyrenaica without any evidence of interbreeding. The present study indicates that *G. eatoni* is a full species and can be distinguished from other species of *Gerbillus* by the same diagnostic characters as set forth by Thomas and by Setzer.

Although this species is not abundant in Libya, and large series are lacking, local differentiation has occurred sufficiently to warrant the recognition of three distinct subspecies, each restricted to a particular portion of the Libyan coastal plain. In Libya, the range of this species probably includes all of the coastal regions and in many areas, the transitory desert associated with the coastal escarpment. It is unknown from the Saharan interior where *G. gerbillus* is the dominant species.

Ecological observations. These gerbils are usually found in areas of loose sand on the coastal plain but frequently occur in habitats lacking sand. In many areas the coastal plain is reduced to a narrow fringe of desolate beach or is entirely eliminated. Thus, these coastal populations of gerbils sometimes occur in a variety of ecological conditions.

Throughout their range in Libya these gerbils occur with several species of jirds (*Meriones*) and jerboas (*Jaculus*), fat-tailed sand rats (*Pachyuromys*), and gerbils of the subgenus *Dipodillus*.

#### *Gerbillus eatoni eatoni* Thomas

*Gerbillus eatoni* Thomas, Proc. Zool. Soc. London, vol. 2, pt. 1, p. 6, October 1902 (El Cusher, Tripolitania Province, Libya).

Specimens examined. Twenty-five, from Cyrenaica: 4 km W Gheminez, 6; 10 km S Agedabia, 8; 5 km W El Agheila, 4 (2 skin only); from Tripolitania: 5 km W Sirte, 4; El Cusher, 1 (subadult BM); 15 km WNW Marble Arch, 2.

Measurements. Averages and extremes of three males and four females from 10 kilometers south of Agedabia, Cyrenaica Province, are, respectively: Total length 214 (208–218), 214.8 (210–222); length of tail 124.3 (117–131), 124.5 (122–126); length of hind foot 27.7 (27–28), 27.3 (26–29); length of ear 14.3 (13–15), 14.5 (13–15); occipitonasal length of skull 28.5 (28.1–28.9), 28.4 (28.1–28.7); length of auditory bulla 10.6 (10.5–10.7), 10.5 (10.3–10.6); crown length of upper molariform toothrow 4 (4–4.1), 4 (3.9–4.2); greatest breadth across zygomatic arches 15.2 (15–15.3), 15.4 (15.1–15.6); least interorbital breadth 5.7 (5.6–5.7), 5.6 (5.4–5.7); breadth of rostrum at

level of antorbital foramina 2.9 (2.8–3), 3 (2.9–3.2); greatest length of nasals 10.6 (10.6–10.7), 10.7 (10.5–10.8).

Diagnosis. Upper parts Sayal Brown suffused with Bister; tail Cinnamon-Buff and bicolored owing to strong suffusion of brownish hairs dorsally; postauricular patches prominent and white; pinna of ear sparsely haired, Clay Color basally and becoming darker distally; vibrissae short and formed from about equal numbers of brown and white hairs; eye ring dark brown; mystacial, rostral and pectoral areas, flanks and sides Cinnamon-Buff; forelegs, hindlegs, and feet white dorsally, sparsely haired ventrally and each bearing five digits with claws; entire underparts white. Skull: Relatively small and gracile; upper molariform teeth relatively short; anterior palatine foramina short and wide; posterior palatine canals relatively short; auditory bullae large and markedly inflated; braincase prominently arched.

Comparisons. Members of the nominate subspecies can be distinguished from those representing other subspecies in Libya by their smaller size and the marked doming of the braincase. For more detailed comparisons with *Gerbillus eatoni inflatus* and *Gerbillus eatoni versicolor*, see accounts of those subspecies.

Remarks. Only a single, subadult topotype of *G. e. eatoni* is available for this study. When specimens of comparable age from various localities along the Gulf of Sirte are compared to this topotype, they differ in having lighter dorsal color, less doming of the skull, and relatively smaller and less inflated auditory bullae. Even though specimens from near Agedabia, Cyrenaica, do not conform precisely to the topotype of *G. e. eatoni*, they constitute a series of sufficient size for comparisons with other subspecies of *G. eatoni* in Libya and in the following accounts will be used to represent the diagnostic characters of typical *G. e. eatoni*.

Specimens from near Gheminez represent the northeasternmost occurrence of gerbils expressing characters typical of *G. e. eatoni* and, in the majority of characters, are referable to the nominate subspecies, but in dorsal color and length of tail, they show intergradation with *G. e. versicolor* to the north.

One old and aberrant male specimen, no. 325311, from Agedabia, shows characters of both *G. e. eatoni* and *G. e. versicolor*. In its marked divergence of the upper molariform toothrows, less domed braincase, and particolored dorsal pelage, it is nearer to *Gerbillus eatoni versicolor*. This specimen is here referred to the nominate subspecies because it resembles the latter in size and degree of inflation of the auditory bullae and in the majority of other cranial characters.

Ecological observations. The habitat at Agedabia is characterized by extensive sandy plains with occasional small dunes. Vegetative cover is relatively dense and composed of bushy succulent shrubs and

other more ephemeral plants. The specimens from near Sirte were collected from the abundant vegetation of the coastal plain. At this locality, the soil is composed of firmly packed clay and sand, and dunes are lacking.

Throughout much of its range in northern Tripolitania, this subspecies occurs with members of *Gerbillus aureus* and *Gerbillus gerbillus*.

***Gerbillus eatoni inflatus*, new subspecies**

Holotype. Adult male, skin and skull, USNM 325527, from 10 km SW Fort Capuzzo, Cyrenaica Province, Libya; obtained June 1, 1962, by G. L. Ranck, original no. 2203.

Specimens examined. Seven, all from the type locality.

Measurements. Averages and extremes of five adult males and the measurements of an adult female, 325528, from the type locality, with the measurements of the type in brackets, are, respectively: Total length 226 (218–236), 219, [225]; length of tail 125 (121–131), 120, [123]; length of hind foot 27.2 (26–28), 27, [26]; length of ear 15.4 (15–16), 16, [15]; occipitonasal length of skull 30.6 (29.9–31.7), 30.2, [30.5]; length of auditory bulla 11.1 (10.7–11.6), 11.2, [11.2]; crown length of upper molariform toothrow 3.9 (3.7–4), 3.9, [3.7]; greatest breadth across zygomatic arches 16.1 (15.6–16.4), 16.2, [16]; least interorbital breadth 5.9 (5.5–6.5), 6.1, [5.6]; breadth of rostrum at level of antorbital foramina 3 (2.8–3.1), 2.9, [3.1]; greatest length of nasals 11.7 (11.4–12.3), 12, [11.5].

Diagnosis. Middorsal region uniformly colored Sayal Brown grading to Clay Color on sides (one specimen, 325559, represents a very old male and is noticeably lighter and more brilliant in dorsal color with decidedly yellowish hues rather than brownish tones); subauricular region suffused with blackish hairs; postauricular patch distinct and white; rostral, mystacial, supraorbital, and pectoral areas, dorsal surfaces of forelegs, hindlegs, feet, and entire underparts white; some specimens with a faint buffy patch on lateral surface of forearm; pinna of ear Antimony Yellow basally and becoming darker distally; anteromedial surface of pinna covered with ochraceous hairs which extend laterally to anterior margin of pinna as a distinct tuft; eye ring black; vibrissae short and formed from equal numbers of light and dark hairs; fore and hind feet sparsely haired ventrally and with five digits bearing claws; ground color of tail uniformly Cinnamon with slight admixture of brownish hairs dorsally and buffy hairs ventrally; pencil indistinct and Avellaneous. Skull: Relatively large and massive; auditory bullae conspicuously large and inflated; braincase moderately vaulted; upper molariform teeth relatively small and toothrow bowing slightly laterally; anterior palatine foramina large and expanded laterally; posterior palatine canals wide and distinct; pterygoid fossae shallow.

Comparisons. Only a subadult, topotypical specimen of *Gerbillus eatoni eatoni* is available for study, and because no specimens of *Gerbillus eatoni inflatus* of comparable age are available, valid comparison is not possible. Specimens of *G. e. inflatus*, however, can be readily distinguished from those representing the nominate subspecies from 15 kilometers west-northwest of Marble Arch, Tripolitania Province, and from 10 kilometers south of Agedabia, Cyrenaica Province, by their darker, more uniform dorsal color, generally larger overall size, and conspicuously larger and more inflated auditory bullae. Members of this subspecies also differ from those representing *G. e. eatoni* in having much wider and less domed braincases, wider and longer posterior palatine canals, relatively shorter upper molariform toothrows, more open pterygoid fossae, and relatively shorter tails.

For comparison with *Gerbillus eatoni versicolor*, see account of that subspecies.

Remarks. Representatives of this subspecies can be separated easily from all other subspecies of *G. eatoni* by their markedly larger and more inflated auditory bullae and larger size of body and cranium.

The type series was taken from a sandy depression in the hamada near the brink of the coastal escarpment. In these localized depressions, the substrate is composed of poorly sorted sand and gravel and supports a rather uniform plant cover of juniper-like species, large grasses, and smaller, woody shrubs. Burrows are usually widespread throughout these areas and suggest relatively high population densities. Jerboas also occur in this habitat.

Although this subspecies is known only from the type locality, its range probably includes the coastal plain and littoral deserts of northern Cyrenaica and those of northern Egypt as far east as the Nile River Delta.

The name *inflatus* refers to the pronounced inflation of the auditory bullae.

***Gerbillus eatoni versicolor*, new subspecies**

Holotype. Adult male, skin and skull, USNM 325298, from 2 km N Coefia, Cyrenaica Province, Libya; obtained June 15, 1962, by G. L. Ranck, original no. 2341.

Specimens examined. Twenty-five, from Cyrenaica: 2 km N Coefia, 16 (2 skin only); 8 km N Benghazi, 9 (1 skin only).

Measurements. Averages and extremes of five adult males and four adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 222.4 (216–236), 221 (205–236), [236]; length of tail 124.2 (119–134), 121.3 (114–130), [134]; length of hind foot 27 (26–28), 27.3 (27–28), [28]; length of ear 16 (15–17), 15.8 (15–16), [15]; occipitonasal length of skull 29.5 (28.7–30.3), 29.2 (28.8–30), [30.3]; length of auditory bulla 10.4

(10–10.8), 10.3 (10–10.6), [10.8]; crown length of upper molariform toothrow 3.9 (3.8–3.9), 3.9 (3.8–4), [3.8]; greatest breadth across zygomatic arches 15.9 (15.4–16.8), 15.8 (15.4–16.5), [16.8]; least interorbital breadth 5.8 (5.5–6.3), 5.8 (5.4–6), [6.3]; breadth of rostrum at level of antorbital foramina 3.2 (3.1–3.4), 3.3 (3–3.4), [3.4]; greatest length of nasals 11.5 (11.4–11.8), 11.4 (11.3–11.6), [11.8].

Diagnosis. Sides and dorsum variegated or particolored ranging from Pinkish-Cinnamon to Cinnamon; all areas, particularly the sides, with admixture of lighter colored hairs; postauricular patch prominent and Light Buff; mystacial, circumorbital, and pectoral areas Pinkish Buff; eye ring black; underparts generally white, but, in some specimens, with a ventromedian line suffused with Light Pinkish Cinnamon; dorsal surface of forelegs, hindlegs, and feet Pale Pinkish Buff; fore and hind feet sparsely haired ventrally and bearing five digits with claws; pinna of ear relatively long and almost naked, Cinnamon-Buff basally and Deep Grayish Olive distally, and with row of delicate buff-colored hairs on anterior margin; vibrissae relatively short and composed of about equal numbers of white and brown hairs; tail faintly bicolored Cinnamon-Buff dorsally and Pinkish Buff ventrally and bearing an indistinct Drab terminal tuft or pencil. Skull: Relatively large and compact; braincase moderately inflated; interorbital region with distinct longitudinal, median fossa; zygomata relatively heavy; upper molariform toothrow relatively short, straight, yet divergent anteriorly; anterior palatine foramina large and widely open; posterior palatine canals markedly wide and bowed slightly laterad; auditory bullae relatively short and moderately inflated; nasals relatively long.

Comparisons. This new subspecies differs markedly from specimens representing *Gerbillus eatoni eatoni* from 15 kilometers west-northwest of Marble Arch, Tripolitania Province, and those from 10 kilometers south of Agedabia, Cyrenaica Province, in darker, more variegated or particolored dorsal pelage (Cinnamon as opposed to Clay Color), more anteriorly divergent and shorter upper molariform toothrows, shorter, narrower, and less inflated auditory bullae, greater length of skull, shorter and wider posterior palatine canals, longer nasals, and less doming of the braincase.

From a subadult, topotypical specimen of *G. e. eatoni* from El Cusher, Tripolitania Province, specimens of comparable age from Coefia are paler in dorsal color, have less distinctly bicolored tails, lack the strong suffusions of brownish hairs on the middorsum, have relatively and absolutely markedly smaller and less inflated auditory bullae, much less inflated braincases, and longer posterior palatine canals.

From specimens representing *Gerbillus eatoni inflatus* from 10 kilometers southwest of Fort Capuzzo, Cyrenaica Province, *G. e. versicolor*

is slightly smaller in overall size, has noticeably shorter and much less ventrally inflated auditory bullae, smaller and more gracile skull, larger upper molariform teeth which form straight toothrows rather than being bowed laterally, narrower and smaller braincase, slightly shorter nasals, paler, more uniform dorsal coloration (Cinnamon as opposed to Sayal Brown), and less prominent subauricular patches.

Remarks. Members of this subspecies can be distinguished from other subspecies of *G. eatoni* in Libya by their particolored dorsal pelage, more parallel upper molariform toothrows, and conspicuously smaller and less inflated auditory bullae.

Specimens from 8 kilometers north of Benghazi are similar to *G. e. inflatus* in more uniform color of dorsum and general body size, but resemble the nominate subspecies in having larger and more domed braincases and more lateral bowing of the upper molariform teeth. In the majority of characters, however, they are closer to *G. e. versicolor* to which they are here referred. A small series from Gheminez, although similar in color to *G. e. versicolor,* is clearly referable to the nominate subspecies in all morphological characters.

The type localities of *G. e. versicolor* and *G. e. inflatus* are, geographically, not too distant, but the Gebel Achdar and the massif of the Cyrenaican Plateau are interposed between them and provide unsuitable habitat for members of this species. Little suitable habitat exists along the coastal plain owing to the encroachment of the coastal escarpment. In the past, gene exchange between these two populations probably has been of rare occurrence, and the two populations have undergone significant morphological divergence.

The type series was collected from an area of large, sparsely vegetated coastal dunes lying between the sea and the coastal plain. It is doubtful if these gerbils are entirely limited to this type of habitat. The gerbils from near Benghazi occupied the rather densely vegetated coastal plain where the substrate was claylike, and sandy areas or dunes were entirely lacking. These gerbils probably are not limited to a particular type of substrate and occur throughout the coastal plain where a wide variety of soil conditions exist.

The name "versicolor," from the Latin meaning variegated or of different colors, refers to the particolored dorsal pelage.

### *Gerbillus gerbillus* (Olivier)

*Dipus gerbillus* Olivier, Bull. Sci. Phil. Paris, vol. 2, p. 121, 1801 (Giza Province, Egypt).

General distribution of species. Israel, Sinai, Egypt, Sudan, Uganda, and North Africa south through the Sahara including parts of Niger, Mauritania, Chad, and Mali.

Distribution in Libya. Almost ubiquitous throughout the coastal and interior areas of Cyrenaica, Tripolitania, and the Fezzan.

Distribution of the subspecies in Libya.

*Gerbillus gerbillus aeruginosus.* Cyrenaica: Cufra and Bzema oases and the serirs and oases of extreme southeastern Libya.

*Gerbillus gerbillus discolor.* Fezzan: Oases, serirs, hamadas, and wadis linking together the various Fezzanese oases.

*Gerbillus gerbillus gerbillus.* Cyrenaica: Environs of Giarabub Oasis.

*Gerbillus gerbillus latastei.* Tripolitania: Desert areas of central Tripolitania and the Hamada el Hamra.

*Gerbillus gerbillus psammophilous.* Cyrenaica: Coastal deserts near Gulf of Sirte, Oases of Gialo and Tazerbo, eastern margins of the Gebel el Harug el Asued, and the intervening Serir of Calanscio.

Published records in Libya. Cyrenaica: Augila, El Giof, Es Sahabi, Gialo, Giarabub (de Beaux, 1932); Benghazi (Toschi, 1951); Tripolitania: Ain Hammam, Wadi Aggar, "Attich Loulileh," "Loumoulieh," "Shup" (Thomas, 1902); Bu Ngem (Toschi, 1951); Fezzan: El Baharia, Gara el Hamra, Hatiet el Fachri, Hatiet er Zeroi, Sebha, Bir el Wasti (de Beaux, 1928); Wadi Tenezoft, Murzuch (Toschi, 1951).

Comparisons. Based on measurements of *Gerbillus dallonii* Heim de Balsac as given in the original description (Heim de Balsac; 1936,

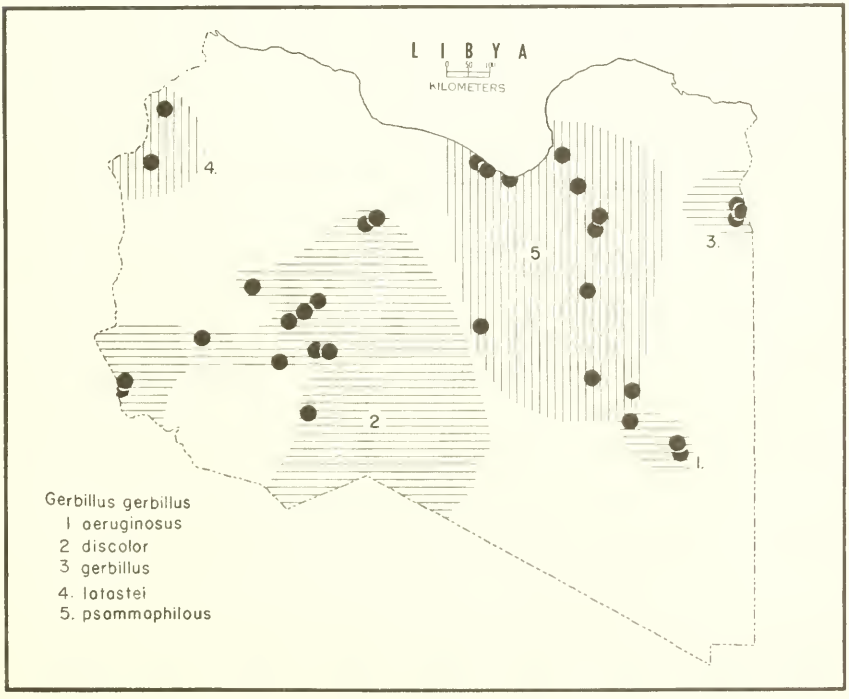


Figure 20.—Distribution of the subspecies of *Gerbillus gerbillus.*

p. 45), *G. gerbillus* can be distinguished by its shorter hind feet, longer rostrum, longer ears, longer molariform toothrow, and markedly larger size of body and cranium.

Remarks. Previous workers in Libyan mammals recognized little variation in *G. gerbillus*, and all of Libya was included within the range of the nominate subspecies. Much larger series are now available from Libya, and this species is now known to be represented by five subspecies and not one as previously supposed.

In many areas of Libya, isolated populations of these gerbils occur throughout seemingly barren wastelands. These areas support only a meager vegetative cover, and frequently plant life is entirely wanting. These widely scattered populations are characterized by common morphological characters which indicate at least some degree of genetic relationship. Apparently, seasonal or occasional rains in these desert areas enable plants, primarily grasses, to undergo their brief life cycle and produce abundant quantities of seed which allow small populations of these gerbils to subsist until the next period of moisture. By successive seasonal or yearly storms, populations of reproductively effective size are able to progressively extend their range. These periods of rainfall may occur within the same year or be spaced over a period of several years. In this manner, small populations of gerbils would be able to "bridge" vast areas in the desert which otherwise would prove insurmountable.

These shifting populations illustrate another significant aspect of distribution. Failure of seasonal or periodic rains can cause the extermination of "bridging" populations just as their occurrence can perpetuate such populations. Failure of rains thus sets up isolating barriers. Occurrence or lack of rain insures a fluctuating pattern of genetic "input" and "output" over the range of the species and also makes it probable that the pattern observed now will be altered in subsequent sampling.

Ecological observations. Members of this species are the most ubiquitous of the subgenus *Gerbillus* in Libya. They are not known to occur in habitats lacking sand and are widely distributed throughout the oases, serirs, and hamadas of the interior. They are commonest along the sandy margins of the oases but occur also in the coastal areas wherever sandy areas are present. They are unknown from the coastal areas of Tripolitania and are not found in Cyrenaica north of the Cyrenaican Plateau. In these areas, they are supplanted by *Gerbillus eatoni* and members of the *Gerbillus pyramidum* group.

Throughout their range in Libya they are sympatric with many other species of rodents but most frequently occur with *Gerbillus pyramidum* and *Jaculus jaculus*.

***Gerbillus gerbillus aeruginosus*, new subspecies**

HOLOTYPE. Adult male, skin and skull, USNM 325146, from El Giof, Cufra Oasis, Cyrenaica Province, Libya; obtained Apr. 3, 1962, by G. L. Ranck, original no. 1920.

SPECIMENS EXAMINED. Eighty-four, from CYRENAICA: Bzema Oasis, 8 (1 skin only); El Hauuari, Cufra Oasis, 36 (1 skin only); El Giof, Cufra Oasis, 40 (2 skin only).

MEASUREMENTS. Averages and extremes of 16 adult males and 8 adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 205 (200–215), 205.4 (200–213), [206]; length of tail 117.7 (109–129), 120 (115–128), [119]; length of hind foot 29.4 (28–32), 28.4 (27–31), [29]; length of ear 13.2 (13–14), 12.8 (12–13), [13]; occipitonasal length of skull 28 (27.3–28.8), 27.4 (26.8–27.8), [28.4]; length of auditory bulla 10.3 (9.8–10.8), 10.3 (10.1–10.7), [10.4]; crown length of upper molariform toothrow 3.5 (3.3–3.7), 3.5 (3.4–3.6), [3.5]; greatest breadth across zygomatic arches 15 (14.6–15.5), 14.7 (14.3–15.1), [14.7]; least interorbital breadth 5.7 (5.4–6.1), 5.7 (5.4–5.9), [5.9]; breadth of rostrum at level of antorbital foramina 3 (2.7–3.3), 3 (2.9–3.1), [3]; greatest length of nasals 10.3 (9.8–10.6), 10.1 (9.7–10.6), [10.4].

DIAGNOSIS. Interauricular, subauricular, interorbital, and rostral areas same color as dorsum and ranging from Ochraceous-Buff, to Clay Color, to tawny-rust; circumorbital, postauricular spots, mystacial and pectoral areas, fore and hind limbs, and entire underparts white; vibrissae short and white; fore and hind feet sparsely haired dorsally and ventrally, and each bearing five digits with claws; pinna of ear almost naked and Pale Orange-Yellow with a row of buffy hairs on anterior margin; tail long and distinctly bicolored, ranging from Capucine Buff to Cinnamon dorsally and from Pinkish Buff to Light Buff ventrally and with a distinct pencil, Light Buff ventrally, and varying in dorsal color from Avellaneous in darker colored individuals to Pale Pinkish Cinnamon in paler animals. Skull: Small and gracile; anterior palatine foramina short and elliptical in shape; posterior palatine canals short and bowed slightly laterally; teeth small; zygomata fragile and convergent anteriorly; braincase slightly inflated and skull rather flattened in profile; auditory bullae moderately inflated ventrally and partially transparent; basioccipitals narrow anteriorly; basisphenoid reduced to a narrow rib between anteromedial edges of auditory bullae; pterygoid fossae large and forming a depression dorsal to pterygoid hamulae; supraorbital bead projecting over dorsal rim of orbit.

COMPARISONS. Compared with topotypical *Gerbillus gerbillus gerbillus* from Alexandria Road, 5 kilometers northwest of the Pyramids

of Giza, Western Desert Governorate, Egypt, *Gerbillus gerbillus aeruginosus* differs in smaller size, shorter tail and hind feet, smaller cranial measurements, heavier zygomata, slightly larger and more divergent upper molariform toothrows, more laterally expanded pterygoid fossae, slightly larger lachrymals, and narrower basioccipitals. In color, *G. g. aeruginosus* is darker dorsally, the tail is less distinctly bicolored, and the buffy dorsal color extends farther ventrally and laterally. In general, the range of color in *G. g. aeruginosus* is much greater than in the nominate subspecies.

Compared with topotypes of *Gerbillus gerbillus asyutensis* Setzer from the beginning of the Wadi el Asyuti, 13 miles southeast of Asyuti, Eastern Desert Governorate, Egypt, *G. g. aeruginosus* differs in darker, more uniform and less variegated dorsal pelage, larger posterior palatine canals, larger molariform teeth, narrower basioccipitals, less ventral inflation of auditory bullae, larger anterior palatine foramina, and larger size of all external and cranial measurements.

Specimens of *Gerbillus gerbillus sudanensis* Setzer from the Anglo-Egyptian Sudan can be readily distinguished from *G. g. aeruginosus* by their paler dorsal color and markedly smaller external and cranial measurements.

From measurements of *Gerbillus gerbillus agag* Thomas from El Fasher, Anglo-Egyptian Sudan, *G. g. aeruginosus* differs in shorter tail, slightly larger body size, shorter skull, shorter molariform toothrow, shorter nasals, and greater breadth across the zygomatic arches. Only three subadult specimens of *G. g. agag* are available for study and, in color, these closely approximate *G. g. aeruginosus.*

*Gerbillus gerbillus aeruginosus* differs markedly from gerbils representing *Gerbillus gerbillus andersoni* de Winton from the vicinity of Alexandria, Egypt. The latter are noticeably larger in all cranial characters, particularly in the size of the anterior palatine foramina, posterior palatine canals, molariform teeth, and the auditory bullae. The skull is more domed and narrower in *G. g. andersoni*, and the dorsum and ears are conspicuously darker.

For comparisons with *Gerbillus gerbillus discolor* and *Gerbillus gerbillus psammophilous*, see accounts of those subspecies.

Remarks. In body and cranial size, animals referable to *Gerbillus gerbillus aeruginosus* are among the smallest of the species of *Gerbillus gerbillus* in Libya. This trend toward small body and cranial size is apparent in all populations of this species to the east and south. *G. g. asyutensis* from central Egypt, *G. g. sudanensis*, and *G.* g. *agag* from the Sudan, and gerbils representing *G. g. aeruginosus* from the Tibesti Area of the Chad, all represent populations of gerbils of small body and cranial size. These common characters may indicate taxo-

nomic relationships among these scattered populations, and when the intervening areas are represented by specimens, they will probably contain intergrades. A clinal gradient of progressive increase in size probably will be demonstrable from east to west.

In most characters, gerbils from Bzema Oasis are referable to *G. g. aeruginosus*, but in greatest length of skull and dorsal color, they show intergradation with *Gerbillus gerbillus psammophilous* to the north. The nearest populations of *G. g. psammophilous* which could provide the gene pool causing these intermediate characters occur in the vicinity of Bir Bu Zarregh and Bir el Harasc north of the Sand Sea of Rebianna. Apparently, then, this sand sea is not an absolute barrier but a filter for genetic exchange between animals strictly referable to *G. g. psammophilous* and *G. g. aeruginosus*.

Animals belonging to *G. g. aeruginosus* are exceptional in their wide range of dorsal coloration, and three distinct groups are recognizable, ranging from Ochraceous-Buff, to Clay Color, to tawny-rust. The majority of individuals are tawny-rust. A genetic response to the local character and color of the sand in Cufra Oasis may account for this wide range of dorsal coloration.

One specimen, 319683, from El Giof, Cufra Oasis, differs markedly from all other specimens of *G. g. aeruginosus* in having a more prominently vaulted skull (especially the parietals), smaller and less inflated auditory bullae, and heavier zygomata. In all other morphological characters this specimen clearly represents *Gerbillus gerbillus*. In the marked inflation of the braincase, however, it resembles *Gerbillus eatoni* whose range includes the Egyptian and Libyan coasts. This similarity to *G. eatoni* is entirely fortuitous, and this specimen is probably aberrant or represents an extreme in the range of variation for the subspecies.

Ecological observations. These gerbils prefer the sandy areas along the periphery of the oasis but occasionally were taken from areas of open sand within the palm groves. At El Giof, a large series was obtained from a sandy clearing in the interior of the oasis. Usually however, *Gerbillus pyramidum* and *Gerbillus campestris* are more abundant in the oasis proper.

At Bzema, El Giof, El Hauuari, and most of the other large oases of southern Cyrenaica, large saline lakes occupy the interior of the oasis and form hard precipitates of salt along their margins. These barren areas are surrounded by a ring of sedges and halophytic plants, and *G. gerbillus* occurs here only sparingly; however, *Gerbillus campestris* occurs abundantly in these mesic habitats.

The name *aeruginosus*, from the Latin meaning rust or rusty, alludes to the rusty dorsal color of most specimens.

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***Gerbillus gerbillus discolor*, new subspecies**

HOLOTYPE. Adult male, skin and skull, USNM 322461, from Ghat, Fezzan Province, Libya; obtained Dec. 18, 1961, by G. L. Ranck, original no. 1116.

SPECIMENS EXAMINED. One hundred sixty-two, from TRIPOLITANIA: 2 km SW Hun, 18; 5 km S Socna, 6; Bir Fergian, 10 km S Socna, 2; from FEZZAN: Edri, 11; Temenhint Oasis, 30 km NE Sebha, 12; 3 km NW Sebha, 5; 5 km NW Sebha, 3 (1 skin only); 10 km SE Sebha, 4 (skin only); El Abiad, 60 km SW Sebha, 18 (2 skin only; 2 skull only); 75 km W Ubari, 11; Meseguin 1; Umm el Araneb, 2; 6 km N Murzuch, 1; 55 km SSW Serdeles, 8; 20 km N Ghat, 1; 12 km N Ghat, 13 (4 skull only); Ghat, 25 (1 skeleton); El Gatrun, 17; El Barcat, 4.

MEASUREMENTS. Averages and extremes of 12 adult males and 6 adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 211 (200–220), 210.7 (200–218), [213]; length of tail 121.6 (112–130), 124.3 (116–128), [125]; length of hind foot 28.6 (28–30), 28.3 (27–29), [29]; length of ear 13.4 (13–14), 13.2 (12–14), [13]; occipitonasal length of skull 28.3 (27–28.9), 27.9 (27.1–29), [28.4]; length of auditory bulla 10.5 (10.1–10.7), 10.3 (10–10.7), [10.6]; crown length of molariform toothrow 3.6 (3.5–3.8), 3.6 (3.5–3.6), [3.6]; greatest breadth across zygomatic arches 15.4 (15.2–15.6), 14.6 (14.5–14.8), [15.6]; least interorbital breadth 5.7 (5.2–6), 5.7 (5.5–5.8), [5.5]; breadth of rostrum at level of antorbital foramina 3.1 (2.9–3.3), 3 (2.9–3), [3]; greatest length of nasals 10.6 (10.2–11.1), 10.3 (9.8–10.6), [10.5].

DIAGNOSIS. Upperparts Clay Color, suffused throughout with brownish hairs imparting a streaked or marbled appearance; subauricular patch prominent and Cinnamon-Buff; pinna of ear sparsely haired and Clay Color; preauricular patch Pinkish Buff and extending as a row of fine hairs onto anterior margin of pinna; postauricular patch, circumorbital, rostral and mystacial areas, dorsal surfaces of fore and hind feet and entire underparts white (in some specimens, the venter is Pale Pinkish Buff owing to artificial staining); fore and hind feet with five digits, each bearing a claw; tail distinctly bicolored Cinnamon-Buff dosally, Light Buff ventrally and terminating in a prominent pencil, Avellaneous dorsally and Light Buff ventrally; vibrissae short and composed of both brownish and whitish hairs. Skull: Medium in size; braincase moderately arched; auditory bullae relatively large and inflated: anterior palatine foramina and posterior palatine canals narrow; zygomata moderately heavy and convergent anteriorly; posterior lacerated foramina between basioccipital and anteromedial margins of auditory bullae reduced to slitlike aperatures.

Comparisons. From topotypes of *Gerbillus gerbillus gerbillus*, the type and paratypes of *G. g. discolor* differ in having narrower anterior palatine foramina and posterior palatine canals, slightly more inflated auditory bullae, shallower pterygoid fossae, shorter skulls, shorter nasals, greater zygomatic breadth, and more robust skulls. Gerbils from the Fezzan are smaller in overall length and length of tail and hind foot; in color, they are noticeably darker and appear more streaked owing to a greater admixture of brownish hairs on dorsum.

Two specimens, 321821 and 321822, from 40 kilometers north of Sinauen and a single specimen, 321825, from 5 kilometers east of Derg, Tripolitania Province, are referable to *Gerbillus gerbillus latastei* and differ from those of *G. g. discolor* in having wider anterior palatine foramina, more gracile zygomata, more vaulted braincases, and larger external and cranial measurements, being of comparable size only in least interorbital breadth and length of nasals. In color, these specimens from Tripolitania are more uniform in dorsal color, with less suffusion of brownish hairs.

When the type series of *G. g. discolor* and *Gerbillus gerbillus aeruginosus* are compared, *G. g. discolor* differs in having slightly paler, more variegated dorsal color, wider and more inflated auditory bullae, narrower posterior palatine canals, larger cheek teeth, proportionately smaller and deeper pterygoid fossae, wider basioccipitals, and markedly larger size of all external and cranial measurements, except length of hind foot and breadth of rostrum at the level of the antorbital foramina.

For comparison with *Gerbillus gerbillus psammophilous*, see account of that subspecies.

Remarks. Gerbils from Edri, near the northern limits of the range of *G. g. discolor*, are similar cranially to topotypes of *G. g. discolor* from Ghat, Fezzan. They are intermediate in color, however, between that of a single representative, 321825, of *Gerbillus gerbillus latastei* from Derg, Tripolitania, and topotypes of *G. g. discolor*. The color of these specimens from Edri suggests a relationship to *G. g. latastei* whose range is to the north. Unfortunately, specimens are not available from the Hamada el Hamra and the Hamada de Tinrhert which are located north of Edri and between the ranges of *G. g. latastei* and *G. g. discolor*. Although sandy habitats are not widespread in these hamadas, localized sandy areas are present and doubtless support small populations of these rodents. These hamadas, therefore, provide an avenue through which gene exchange takes place between populations of *G. g. latastei* to the north and those of *G. g. discolor* to the south. Gerbils inhabiting these regions may be intergrades between these two subspecies.

Representatives of this subspecies from El Gatrun on the eastern margin of the Idehan Murzuch are paler in dorsal color than those from elsewhere in the Fezzan. When specimens of *Gerbillus gerbillus* become available from the Serir Tibesti and other regions to the south, they may represent an undescribed subspecies to which the specimens from El Gatrun will be referable.

Gerbils from El Abiad, 55 kilometers west of Ubari, 75 kilometers south-southwest of Serdeles, and 12 kilometers north of Ghat are remarkably uniform in color and cranial characters. Apparently the sandy beds of the Wadi el Agial, Wadi Irauen, and the Wadi Tenezoft act as dispersal corridors which insure genetic uniformity among these widely scattered populations.

Members of this subspecies from the vicinity of Hun, Socna, and Bir Fergian, Tripolitania Province, show many characters typical of *Gerbillus gerbillus psammophilous*, whose range includes most of Cyrenaica and the coastal areas of the Gulf of Sirte. In the degree of inflation of the auditory bullae, breadth of the anterior palatine foramina, and the size and shape of the posterior lacerated foramina between the basioccipital and auditory bullae, they resemble *G. g. psammophilous*, but in the majority of cranial characters, they are closer to *G. g. discolor* to which they are here referred. For additional comments regarding gene exchange with *G. g. psammophilous*, see under "remarks" in account of that subspecies.

Although this subspecies is characterized by generally darker, more variegated dorsal color, individuals in the population range from uniform colors of pale, subdued tones to rather brilliant, ochraceous hues. Partial albinism is also of occasional occurrence. In gerbils from Sebha and Temenhint Oases of the central Fezzan, this broad range in dorsal color is particularly striking. These oases apparently represent areas in which the genetic character of the population is less rigidly fixed.

These small gerbils are probably the most widely distributed rodent in the Fezzan. They are most abundant near the periphery of the oases where the palm groves are less dense and open sandy areas are more widespread. In the Fezzan, *G. g. discolor* is sympatric with the larger, and usually more abundant, *Gerbillus pyramidum tarabuli*. Other rodents, such as *Gerbillus amoenus*, *Jaculus jaculus*, *Meriones caudatus*, and *Acomys cahirinus* occur with *G. gerbillus* but usually are far less abundant.

The range of this subspecies, as far as is known, does not include coastal Libya. In the coastal areas of northern Tripolitania, members of the *Gerbillus pyramidum* group are the dominant gerbils.

The term *discolor*, from the Latin meaning "of different color or colors," is used for the subspecies name in reference to the variegated character of the dorsal pelage.

***Gerbillus gerbillus gerbillus* (Olivier)**

*Dipus gerbillus* Olivier, Bull. Sci. Soc. Philom., Paris, vol. 2, p. 121, 1801 (Giza Province, Egypt).

Specimens examined. Twenty-six, from Cyrenaica: Giarabub, 10 (1 skin only); Bahr el Tubat, 21 km ESE Giarabub, 11; 24 km SSE Giarabub, 5.

Measurements. Averages and extremes of five males and measurements of two females from Giarabub are, respectively: Total length 214 (205–221), 214, 205; length of tail 127 (121–135), 122, 119; length of hind foot 29 (28–30), 31, 32; length of ear 13 (13–13), 12, 13; occipitonasal length of skull 28.7 (28.1–29.4), 28.1, 27; length of auditory bulla 10.7 (10.2–11.2), 9.9, 10.2; crown length of molariform toothrow 3.7 (3.6–3.8), 3.4, 3.6; greatest breadth across zygomatic arches 15.3 (14.5–15.8), 14.7, 14.9; least interorbital breadth 5.9 (5.7–6), 5.6, 5.5; breadth of rostrum at level of antorbital foramina 3 (3–3.1), 3, 2.8; greatest length of nasals 10.6 (9.9–11.6), 10.6, 10.4.

Diagnosis. Upperparts Cinnamon-Buff becoming paler on sides and flanks owing to suffusion of whitish hairs; circumorbital regions, mystacial and pectoral areas, dorsal surfaces of fore and hind feet, and entire underparts white; postauricular patch distinct and white; vibrissae short and composed of brownish and white hairs; pinna of ear almost naked, Warm Buff, and with row of fine, buffy hairs on anterior margin; fore and hind feet sparsely haired ventrally and bearing five digits, each with a claw; tail indistinctly bicolored Light Ochraceous-Buff above and Light Buff below, and with a prominent terminal pencil, Tilleul-Buff dorsally and Pale Pinkish Buff ventrally. Skull: Medium in size and moderately robust; zygomata heavy; lachrymals large; molariform teeth moderately large; auditory bullae markedly large and inflated; braincase moderately domed.

Comparisons. From topotypical *Gerbillus gerbillus gerbillus* from Alexandria Road, 5 miles northwest of the Pyramids of Giza, Cairo Area, Egypt, specimens from Giarabub and vicinity differ in having slightly heavier zygomata, larger lachrymals, larger and more inflated auditory bullae, slightly larger molariform teeth, slightly narrower basioccipitals and shorter overall size of body. In color, the majority of specimens are closer to *Gerbillus gerbillus psammophilous*, whose range is farther west and south. In the majority of cranial characters and in external measurements, however, they resemble the nominate subspecies to which they are here referred.

For comparisons with *Gerbillus gerbillus aeruginosus* and *G. g. psammophilous*, see accounts of those subspecies.

Remarks. In cranial characters, these specimens from Giarabub are indistinguishable from those from Bahr el Tubat and Siwa Oasis, western Egypt. These populations also do not differ significantly

from those from the type locality. Apparently, the low-lying areas associated with the Wadi Natroun, Qattara Depression, Siwa Oasis, and Bahr el Tubat provide a continuum of suitable habitat linking these various populations together.

In some characters, notably heavy zygomata, large and ventrally inflated auditory bullae, narrow basioccipital and small body size, these gerbils from Giarabub show evidences of gene exchange with *G. g. psammophilous* to the west. Apparently they are able to overcome the barrier imposed by the Sand Sea of Calanscio in this region of Libya.

Some gerbils from Giarabub are noticeably darker, more orangish in dorsal color, than others. This same feature was observed in jerboas (*Jaculus jaculus*) from Giarabub and is presumably an adaptive response to the different color of the sand in this area.

Ecological observations. Giarabub Oasis is a portion of the great depression formed from the east-west linkage of the Wadi Natroun, Qattara Depression, and Siwa Oasis. Although located in the interior of the desert, all three "sebchets" are below sea level. Sandy areas of large extent have accumulated here and provide desirable habitat for these gerbils. Plant cover is more abundant in these low-lying areas than elsewhere; dense stands of *Phragmites* are widespread in the bottoms of the depressions; and *Tamarix* occupies the more elevated areas where the soil is firmer and more stable. Various other species of woody shrubs are also present. Many resemble the chenopods, woody composites, and thorny perennials of the western United States. The series from Giarabub was obtained from some large dunes near the oasis.

A concentration of sandy-clay hummocks within a localized sandy elevation of the valley floor formed the habitat at the collecting site 24 kilometers south-southeast of Giarabub. The vegetative cover here was particularly dense and varied.

Bahr el Tubat is a large, quite shallow, saline lake surrounded, in some places, by dense stands of reeds and sedges. In other areas of the shoreline, salty deposits of great thickness and extent occur, rendering the habitat unsuitable for mammals. The specimens from Bahr el Tubat were taken from a series of vegetated dunes beyond the lake and slightly higher in elevation.

### *Gerbillus gerbillus latastei* Thomas and Trouessart

*Gerbillus gerbillus latastei* Thomas and Trouessart, Bull. Soc. Zool. France, ser. 5, vol. 28, pp. 171–174, July 28, 1903 (Kebili, Southern Tunisia).

Specimens examined. Three, from Tripolitania: 40 km N Sinauen, 2; 5 km E Derg, 1.

Measurements. The measurements of an adult male, 321822, and female, 321821, from 40 kilometers, north of Sinauen, and of an adult male, 321825, from 5 kilometers east of Derg are, respectively: Total length 219, 215, 217; length of tail 128, 130, 130; length of hind foot 30, 30, 29; length of ear 14, 14, 13; occipitonasal length of skull 29.3, 28, 28.7; length of auditory bulla 10.8, 10.5, 10.5; crown length of upper molariform toothrow 3.8, 3.7, 3.8; greatest breadth across zygomatic arches ?, 14.6, ?; least interorbital breadth 5.7, 5.6, 6.1; breadth of rostrum at level of antorbital foramina 3.3, 2.9, 3.1; greatest length of nasals 10.6, 10.6, 10.6.

Diagnosis. Upperparts lustrous, Clay Color with uniform admixture of brownish hairs extending over sides of body nearly to the venter where it has greater suffusion of whitish hairs; subauricular patches distinct, Cinnamon-Buff and also with admixture of brownish hairs; mystacial, rostral, preauricular, and circumorbital areas, postauricular patch, dorsal surfaces of fore and hind feet, and entire underparts white; pinna of ear almost naked, Ochraceous-Buff, and with row of buffy hairs on anterior margin; vibrissae short and white with occasional darker hairs; fore and hind feet sparsely haired, with five digits, each bearing a claw; tail distinctly bicolored Cinnamon-Buff dorsally, white ventrally, with prominent terminal pencil, Avellaneous dorsally and white ventrally. Skull: Relatively large, molariform teeth long; interorbital breadth moderately wide; nasals short, auditory bullae and posterior palatine canals large; zygomata markedly fragile and convergent anteriorly; supraorbital bead prominent; braincase moderately vaulted.

Comparisons. The two specimens, 321821 and 321822, from near Sinauen and the single specimen, 321825, from Derg differ from topotypes of the nominate subspecies in darker color, more streaked and lustrous dorsal pelage, slightly smaller overall length, slightly longer ears, slightly longer skulls, longer molariform teeth, narrower interorbital breadth, slightly shorter nasals, larger auditory bullae, and longer posterior palatine canals.

Compared to a single topotype (MNHN 57) of *Gerbillus gerbillus foleyi* Heim de Balsac from Beni Abbes, western Algeria, the specimens from Libya are similar in dorsal color, but differ in having smaller hind feet and auditory bullae, narrower zygomatic breadths, and slightly shorter nasals.

For comparisons with *Gerbillus gerbillus discolor* and *Gerbillus gerbillus psammophilous*, see accounts of those subspecies.

Remarks. The specimens from near Sinauen are slightly darker in dorsal color than the specimen from Derg and also have larger auditory bullae, shorter posterior palatine canals, and more vaulted

braincases. These differences are too slight to warrant assignment of these specimens to separate subspecies, and they are here referred to the same subspecies.

Ellerman and Morrison-Scott (1951) considered *G. g. latastei* to be a little-known and dubious form. In the present study comparative specimens of *G. g. latastei* are not available, but Thomas and Trouessart (1903), in the original description, included the following measurements: Length of head and body, 97; length of tail, 110; length of hind foot, 27.5; length of ear, 12; length of skull from the tip of the nasals to the extremity of the interparietal, 31; length of nasals, 12.5; interorbital breadth, 6.3; length of diastema, 8.5; length of the upper molariform toothrow, 4.4. In the original description *latastei* was also characterized as having patches above the eyes and behind the ears, all underparts pure white, hairs grayish at the base, except the postauricular patches which are entirely white, and the dorsal color of the tail the same color as the back and white below with a small brownish pencil. According to Thomas and Trouessart, it can be distinguished from all other gerbils by its brilliant color. The three specimens from Tripolitania agree closely with the above color description but are somewhat smaller in most cranial characters and larger in most external measurements. Owing to inadequate comparative materials, the assignment of these specimens to *G. g. latastei* is provisional and based largely on geographic grounds.

The specimens from near Sinauen were taken from a broad slope in the hamada where vegetation was sparse and interspersed with small, transient dunes. The habitat at Derg was similar to that at the above locality, but the plant cover was more abundant and confined to margins of a small wadi, and the sand was more sporadic and localized.

This subspecies probably has a much larger distribution in Libya than the few specimens would indicate, and the range probably includes a large portion of the Hamada el Hamra, the Hamada de Tinrhert, and the inner margins of the Tripolitanian coastal plain.

#### *Gerbillus gerbillus psammophilous*, new subspecies

Holotype. Adult male, skin and skull, USNM 325078, from Gialo Oasis, Cyrenaica Province, Libya; obtained Mar. 16, 1962, by G. L. Ranck, original no. 1790.

Specimens examined. One hundred eighty, from Cyrenaica: 10 km S Agedabia, 27 (2 skin only); 65 km WNW El Agheila, 1; 5 km W El Agheila, 2; Gasr es Sahabi, 12 (6 skull only); Augila, 23; Gialo Oasis, 58; 150 km S Gialo, 1; Wadi er Rueis, 340 km WNW Tazerbo, 3; El Gezira, Tazerbo Oasis, 16; Tazerbo Oasis, 23; Bir bu Zarregh, 3; Bir el Harasc, 9; from Tripolitania: 15 km WNW Marble Arch, 2.

Measurements. Averages and extremes of 31 adult males and 18 adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 214.4 (202–220), 208.1 (200–220), [210]; length of tail 122.5 (117–129), 120.3 (113–128), [122]; length of hind foot 29.4 (28–31), 28.6 (27–30), [29]; length of ear 13.9 (13–14), 13.3 (13–14), [14]; occipitonasal length of skull 28.6 (27–29.9), 28.1 (27.3–29.5), [28.5]; length of auditory bulla 10.4 (9.8–11), 10.3 (9.7–10.9), [10.5]; crown length of upper molariform toothrow 3.6 (3.4–3.9), 3.6 (3.4–3.9), [3.7]; greatest breadth across zygomatic arches 15.5 (15–16.4), 15.1 (14.7–15.4), [15.7]; least interorbital breadth 5.9 (5.4–6.4), 5.7 (5.3–6.2), [5.7]; breadth of rostrum at level of antorbital foramina 3 (2.7–3.2), 3.1 (2.9–3.2), [3]; greatest length of nasals 10.6 (10.4–11.6), 10.5 (10–11.3), [10.6].

Diagnosis. Upperparts uniformly Cinnamon-Buff becoming interspersed with white hairs on sides and pectoral areas; circumorbital region, rostral area, postauricular areas, and entire underparts white; fore and hind feet Light Buff dorsally, sparsely haired ventrally, and each bearing five digits with claws; pinna of ear Warm Buff, finely haired and with thin row of buffy hairs along anterior margin; vibrissae short and usually white, but with occasional darker hairs present; tail indistinctly bicolored Light Buff ventrally with narrow dorsal line of Light Ochraceous-Buff terminating in a distinct pencil, Avellaneous dorsally and Light Buff ventrally. Skull: Medium in size; moderately robust; auditory bullae moderately inflated; zygomata heavy; basioccipital constricted anteriorly and forming distinct foramina near anteromedial margins of auditory bullae; external pterygoid fossae forming distinct depressions dorsal to posteriorly flaring pterygoid hamulae; braincase moderately vaulted.

Comparisons. From topotypes of *Gerbillus gerbillus discolor* from Ghat, Fezzan Province, *Gerbillus gerbillus psammophilous* differs in having narrower auditory bullae, more anteriorly constricted basioccipitals, larger foramina between basioccipital and auditory bulla, more arched braincase, less divergent pterygoid hamulae, greater occipitonasal length, greater interorbital breadth, and slightly larger hind feet. In color, *G. g. psammophilous* is much paler and less streaked dorsally and has a less prominent subauricular patch and a lighter pencil.

*Gerbillus gerbillus psammophilous* differs from topotypical specimens of *Gerbillus gerbillus gerbillus* in having heavier zygomata, more anteriorly constricted basioccipitals, more distinct foramina between the basioccipitals and the auditory bullae, smaller, more slitlike posterior palatine canals, shorter overall length, slightly larger occipitonasal length, greater breadth across zygomatic arches, longer

nasals, and rostra less decurved distally. These gerbils are similar to those of the nominate subspecies in dorsal color but appear slightly paler owing to a greater suffusion of whitish hairs on sides, more white around the eyes and rostrum, less prominent subauricular patches, and a paler pencil.

Gerbils representing the nominate subspecies from the vicinity of Giarabub, Cyrenaica Province, resemble those referable to *G. g. psammophilous* but have larger, more massive skulls, larger, more inflated auditory bullae, and larger anterior palatine foramina. In color, they are almost indistinguishable from topotypes of *G. g. psammophilous*.

*Gerbillus gerbillus psammophilous* can be readily distinguished from topotypical specimens of *Gerbillus gerbillus andersoni* by much paler, more orangish dorsal color, shorter anterior palatine foramina, less vaulted braincase, less ventrally inflated auditory bullae, shorter and smaller molariform toothrow, more prominent supraorbital bead, less robust zygomata, and smaller size of all cranial measurements.

From topotypes of *Gerbillus gerbillus asyutensis* from the Wadi Asyuti, Egypt, *G. g. psammophilous* differs in having markedly darker, less variegated dorsal pelage, shorter posterior palatine canals, wider basioccipitals, and larger size of all cranial measurements.

Compared with two specimens, 321821 and 321822, representing *Gerbillus gerbillus latastei* from 40 kilometers north of Sinauen, Tripolitania Province, *G. g. psammophilous* has slightly smaller and more ventrally inflated auditory bullae; smaller molariform teeth; heavier zygomata; shorter occipitonasal length; shorter tail; markedly paler, more subdued dorsal color with less suffusion of brownish hairs; a less distinctly bicolored tail; and vibrissae with fewer dark hairs.

Paratypes of *G. g. psammophilous* can be distinguished from the type and paratypes of *Gerbillus gerbillus aeruginosus* from El Giof, Cufra Oasis, by their paler dorsal color and markedly larger size of all cranial measurements, being similar in length of auditory bulla, crown length of upper molariform toothrow, and least interorbital breadth. *G. g. psammophilous* also has narrower posterior palatine canals, heavier zygomata, more ventrally inflated auditory bullae, less domed skull, and less distally decurved rostrum.

Remarks. Members of this subspecies show significant intergradation with other subspecies whose major ranges are far removed geographically. Gerbils from Giarabub and Bahr el Tubat, in some characters, suggest intergradation between *G. g. psammophilous* and the nominate subspecies. In color, gerbils from Tazerbo Oasis, Bir el Harasc, and Bir bu Zarregh show evidences of gene exchange with *G. g. aeruginosus* to the south. Specimens from near Hun, Socna, and

Bir Fergian, Tripolitania Province, are intermediate in color and cranial characters between gerbils from the Fezzan and those from Cyrenaica.

The Sand Sea of Calanscio to the east and the Sand Sea of Rebianna to the south apparently do not act as absolute barriers to the movements of these gerbils. Likewise, the volcanic ramparts of the Gebel el Harug el Asued of eastern Tripolitania and western Cyrenaica do not entirely limit the east-west dispersal of this species in Libya. Three specimens from the Wadi er Rueis, 340 kilometers west-northwest of Tazerbo are indistinguishable from those from the type locality in color and cranial characters. A pathway for gene exchange between populations of gerbils from the Fezzan and Cyrenaica is provided by the numerous small oases that circumscribe the Gebel el Harug el Asued. When specimens become available from these areas, they probably will show characters allying them to populations of gerbils in both the Fezzan and Cyrenaica.

Cranially, gerbils from the coastal areas near Agedabia, Marble Arch, and El Agheila are indistinguishable from those from the type locality in the Saharan interior. In color, however, these animals from the coast are much paler dorsally with greater suffusion of whitish hairs. This trend toward darker dorsal color increases progressively toward the south and reaches its extreme in gerbils from Tazerbo and Cufra Oases. A single specimen, 325105, from 150 kilometers south of Gialo is intermediate in dorsal color between gerbils from Tazerbo and Gialo Oases. Similarly, specimens from Gasr es Sahabi, which is located midway between Gialo Oasis and the coast are lighter than those from Gialo but darker than those from the coastal deserts. Thus a north-south, clinal gradient in dorsal color is demonstrable within populations of gerbils from Cyrenaica. This gradient in dorsal color reaches its greatest intensity in gerbils inhabiting the southern oases.

Ecological observations. These gerbils range throughout the sandy environs of the oases, where they are frequently associated with debris near the bases of palm trees. They also occur in sandy margins of wadis and frequently inhabit the margins of the sand seas or "Ramleh" where unstable, mountainous dunes are widespread. The larger sand seas, however, such as Rebianna and Calanscio, contain vast areas of constantly shifting dunes which probably are not inhabited by these mice. Apparently sand seas of small extent are not barriers to dispersal. The widely scattered distribution of this subspecies and the collecting sites at 150 kilometers south of Gialo and from the Wadi er Rueis confirm this.

In the coastal areas of Cyrenaica this species is supplanted by *Gerbillus eatoni*, which prefers the more densely vegetated margins of the coastal plain.

The subspecies name *psammophilous*, from the Greek meaning "sand lover," suggests a predilection of members of this subspecies for habitats of a sandy character.

### *Gerbillus pyramidum* E. Geoffroy

*Gerbillus pyramidum* E. Geoffroy, Catalogue des mammifères du Museum National d'Histoire Naturelle, p. 202, 1803 (near Pyramids of Giza, Giza Province, Egypt).

General distribution of species. Israel, Sinai, Egypt, Libya, Algeria, Tunisia, and Morocco; southward throughout the Sahara to central Sudan, Chad (Tibesti Mountain Area), Niger, and Mauritania.

Distribution in Libya. Desert and coastal regions of Tripolitania and throughout the Fezzan. (Only a single specimen is known from Cyrenaica.)

Distribution of the subspecies in Libya.

*Gerbillus pyramidum hamadensis*. Tripolitania: Coastal areas and interior deserts of Tripolitania north of the Gebel es Soda and Hamada de Tinrhert.

*Gerbillus pyramidum tarabuli*. Fezzan.

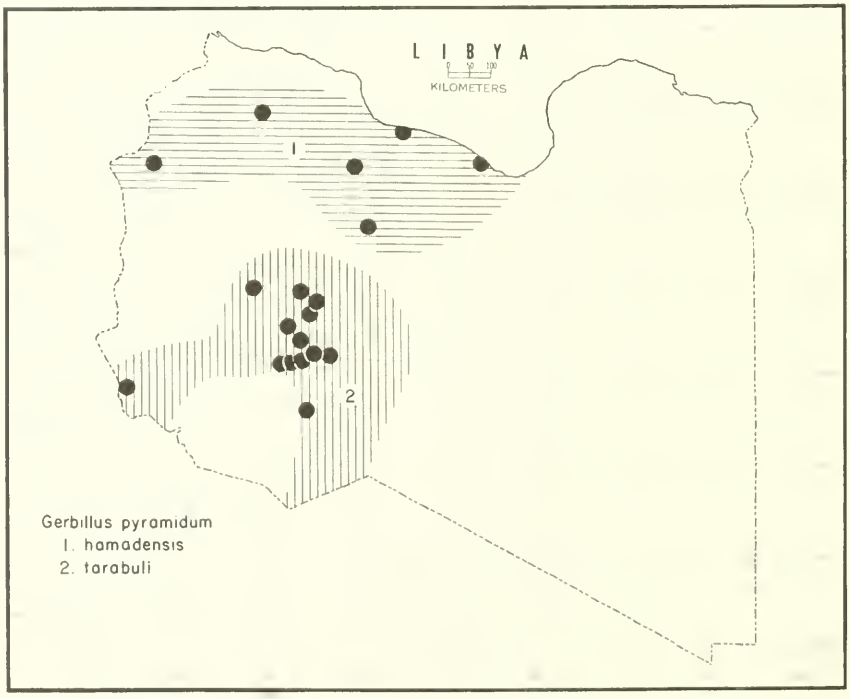


Figure 21.—Distribution of the subspecies of *Gerbillus pyramidum*.

Published records in Libya. Cyrenaica: Vicinity of Benghazi (Ghigi, 1920). The occurrence of this species this far north in Cyrenaica is questionable. While I have not examined these specimens, it seems likely that they would be representatives of *Gerbillus eatoni*; Tripolitania: Wadi Agarib, Wadi Aggar, Ain Hammam, Ferdjan, El Koshby, Linzerat, Wadi Sultan, Tamari-Ferdjan (Thomas, 1902); Gargaresch, Tripoli (Andreucci, 1914); Ghadames (Perugini, 1929); Giofra, Tripolitania settentrionale (Zavattari, 1937); Fezzan: Goddua, Sebha, Umm el Abid, Zeigen (Thomas, 1902); Murzuch (Andreucci, 1914); Sciati, Hofra (Zavattari, 1937).

Comparisons. From *Gerbillus aureus*, which it somewhat resembles, this species can be distinguished by its larger skull and body, longer and more tufted tail, generally lighter color, longer and narrower posterior palatine canals, and relatively narrower anterior palatine foramina.

This species can be distinguished from *Gerbillus eatoni* by its markedly larger overall size (occipitonasal length usually more than 30 mm), relatively smaller and less inflated auditory bullae, larger molariform teeth, and less domed, almost flattened braincase.

This species is markedly larger in all respects than *Gerbillus gerbillus* and has relatively larger molariform teeth, less inflated auditory bullae, and less orange color in the dorsal pelage.

*Gerbillus pyramidum* closely resembles *Gerbillus perpallidus* Setzer from Egypt but can be distinguished by its darker color, markedly larger skull, less inflated auditory bullae, more open pterygoid fossae, longer anterior palatine foramina, and much more conspicuous supraorbital beads. The foregoing characters were used by Setzer (1958 p. 221) to separate these two species and I concur.

Remarks. These gerbils are widely distributed throughout North Africa from the Red Sea to the Atlas Mountains and occur virtually throughout the Sahara; however, there is a conspicuous hiatus in their distribution in western Egypt and eastern Libya. In Libya, the oases of Gialo, Giarabub, Tazerbo, and Cufra, and in Egypt, Siwa Oasis and the low-lying areas of the Qattara Depression contain abundant suitable habitat for them, but as yet, no specimens are known from these areas. Apparently, members of this species are unable to circumvent the barriers imposed by the Cyrenaican Plateau and the northern part of the Libyan Desert and have been unable to extend their range into these parts of Libya and Egypt. In Libya, the Serir of Calanscio and the Sand Sea of Calanscio doubtless serve to further isolate the oases in southern Cyrenaica.

This species occurs abundantly throughout western Libya in the provinces of Tripolitania and Fezzan. Presently, these populations in Libya are linked to those of the Nile Valley in Egypt by a series

of rather discontinuous populations throughout the northern Chad and west-central Sudan. In the future, when more localities become represented by specimens, it is probable that a more clearly defined dispersal route, consisting of several overlapping populations, will be found to unite the Libyan populations with those of the type locality in the Nile Valley.

Prior to the present study, Ellerman and Morrison-Scott (1951) included Algeria within the range of *G. p. pyramidum*, based, apparently, on specimens from El Golea and In Salah. It is now known that the range of the nominate subspecies is confined to Egypt (including Sinai) and Sudan as far south as Khartoum. The range of *G. p. tarabuli* thus is interposed between the areas of occurrence of these Algerian populations and the type locality. Such a discontinuous distribution for members of the same subspecies is untenable, and I suspect that these gerbils from central Algeria represent subspecies distinct from those in Libya and Egypt.

***Gerbillus pyramidum hamadensis*, new subspecies**

Holotype. Adult male, skin and skull, USNM 321827, from 5 km E Derg, Tripolitania Province, Libya, obtained Nov. 14, 1961, by G. L. Ranck, original no. 886.

Specimens examined. Fifty-five, from Cyrenaica: 5 km W El Agheila, 1; from Tripolitania: 5 km N Mizda, 3; 12 km W Sirte, 2; 15 km WNW Marble Arch, 3; 30 km S Bu Ngem, 2; 5 km E Derg, 13; 5 km S Socna, 15; Bir Fergian, 10 km S Socna, 17 (16 skin only).

Measurements. Averages and extremes of six adult males and five adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 240.2 (235–244), 228 (223–234), [244]; length of tail 141 (137–145), 131.4 (128–135), [145]; length of hind foot 30.2 (29–32), 31 (29–32), [29]; length of ear 14.8 (14–16), 15.2 (14–16), [16]; occipitonasal length of skull 31.6 (31–32), 30.5 (29.7–31.4), [32]; length of auditory bulla 11.7 (11.4–11.9), 11.5 (11.2–11.7), [11.6]; crown length of upper molariform toothrow 4.3 (4.1–4.4), 4.2 (4–4.4), [4.2]; greatest breadth across zygomatic arches 16.7 (15.7–16.9), 16.2 (15.8–16.8), [16.6]; least interorbital breadth 6.5 (6–6.8), 6.3 (6–6.6), [6.8]: breadth of rostrum at level of antorbital foramina 3.6 (3.5–3.8), 3.6 (3.5–3.8), [3.6], greatest length of nasals 12.3 (11.8–12.6), 11.7 (11.3–12), [12.6].

Diagnosis. Upperparts Cinnamon-Buff grading to Clay Color and Tawny-Olive on rump and becoming paler on sides; entire dorsum lightly washed with brownish hairs which project appreciably beyond the paler colored underlying hairs; subauricular areas Cinnamon-Buff with slight suffusion of grayish-brown hairs; supraorbital, rostral, mystacial, circumoral, and pectoral areas pure white; postauricular

patches distinct and pure white; pinna of ear same color as dorsum, sparsely haired and with row of buffy hairs along anterior margin; vibrissae composed of nearly equal numbers of brown and white hairs; dorsal and ventral surfaces of fore and hind feet white, densely haired and each bearing five digits with claws; tail indistinctly bicolored, Pinkish Buff dorsally and Pale Pinkish Buff ventrally, and terminating in a conspicuous brownish-colored pencil; entire underparts white. Skull: Relatively small; rostrum wide; molariform teeth relatively large; anterior palatine foramina markedly narrow and slitlike; auditory bullae rather bulbous.

Comparisons. From *Gerbillus pyramidum pyramidum* as known from several localities in Giza Province, Egypt, *Gerbillus pyramidum hamadensis* differs in markedly smaller size of body and skull, relatively smaller and more slitlike anterior palatine foramina, less ventrally inflated auditory bullae, less robust zygomata, and smaller lachrymals. This subspecies is much paler and uniform in dorsal color and has more prominent postauricular patches and lighter colored pencil.

Compared with topotypes of *Gerbillus pyramidum tarabuli*, *G. p. hamadensis* is noticeably smaller in all cranial and external characters, being of comparable size only in crown length of molariform toothrows and breadth of rostrum. In color, members of this new subspecies are slightly paler, have a grayer cast owing to a greater suffusion of grayish hairs on dorsum, and have a pencil of a slightly lighter color.

These gerbils can be readily distinguished from representatives of *Gerbillus pyramidum hirtipes* Lataste from Ain Sefra, southwestern Algeria, by paler dorsal color, longer and more thickly tufted tails, larger auditory bullae and molariform toothrows, and generally larger size of all other measurable cranial characters.

In general body size and length of hind foot and ear, *G. p. hamadensis* resembles *Gerbillus aureus nalutensis* but differs markedly in having smaller anterior palatine foramina, longer posterior palatine canals, more robust zygomata, larger molariform teeth, longer and more tufted tail, paler and less varied dorsal color with less suffusion of black on rump, and larger size of all cranial measurements.

Remarks. Members of this subspecies can be distinguished from all others in Libya by their conspicuously smaller size and paler dorsal color. Throughout the range of this subspecies, animals vary locally. Gerbils from 5 kilometers south of Socna, Tripolitania Province, are more strongly suffused with brown on the back and dorsum of tail, have slightly darker pencils, slightly longer and wider anterior palatine foramina, more gracile skulls, less prominent supraorbital ridges, and are slightly smaller in all cranial measurements. Two specimens, 322097 and 322098, from 30 kilometers south of Bu Ngem, Tripolitania Province, have slightly smaller anterior palatine foramina, but, in

color, are indistinguishable from gerbils from Socna and Bir Fergian. Members of this subspecies from various localities in the coastal plain tend to have slightly larger, more bulbous auditory bullae. Those from 12 kilometers west of Sirte are also darker in dorsal color. This variation is well within the expected limits of a subspecies whose range includes such a large geographic area.

The populations from Socna and Bir Fergian show only slight intergradation with *G. p. tarabuli* whose range is to the south. Gerbils from the type locality at Derg show no evidences of interbreeding with populations to the south. The high escarpments of the Hamada de Tinrhert in the west and the mountain ramparts of the Gebel es Soda and the Gebel el Harug el Asued in the east obviously have proven to be serious deterrents to gene exchange between populations of these gerbils, and thus the range of this subspecies is limited to the hamadas, coastal deserts, and coastal plain lying north of these barriers. In northwestern Tripolitania the range of this subspecies apparently does not attain the Mediterranean Coast. Three specimens from 5 kilometers north of Mizda constitute the northernmost record of occurrence of *G. pyramidum* in Libya. Farther north, *Gerbillus aureus* is the dominant gerbil and probably competes with and thus prevents *G. pyramidum* from occupying the coastal areas. Farther eastward, however, along the Gulf of Sirte, *G. aureus* is known only from Sirte, while *G. p. hamadensis* is known from several localities.

Ecological observations. The type series was obtained from the rather denuded margins of a small wadi in the western portion of the Hamada el Hamra. This dry watercourse afforded scanty vegetative cover, while rocky outcroppings interspersed with bare areas of sand and gravel were widespread. In the immediate vicinity of the wadi, *Tamarix*, *Calligonum*, and other types of shrubs were the dominant vegetation, but farther out on the hamada, smaller plants growing close together were commoner. The soil in this area consisted mostly of sand.

Setzer (1957) describes the habitat at Socna and Bir Fergian as consisting of a sandy-clay substrate similar to hardpan, which resembles the desert playas of the Western United States. The collecting sites in the coastal plain near Sirte, Marble Arch, and El Agheila were characterized by dense plant cover and the soil in these areas also was sandy-clay. Large, permanent dunes supporting *Calligonum* characterized the habitat near Bu Ngem. Judging from the sandy character of these habitats, this subspecies always requires a sandy substrate.

The name *hamadensis* refers to the hamada-like character of the habitat at the type locality and several other collecting sites of this subspecies.

### *Gerbillus pyramidum tarabuli* Thomas

*Gerbillus pyramidum tarabuli* Thomas, Proc. Zool. Soc. London, vol. 2, pt. 1, p. 5, October 1902 (Sebha, Fezzan Province, Libya).

Specimens examined. Three hundred thirty-one, from Fezzan: Brach, 22, Edri, 12; Temenhint, 34; 4 km N Sebha, 10; 5 km NW Sebha, 8; 3 km NW Sebha, 10; Sebha, 19 (2 BM); 7 km SW Sebha, 5; 10 km SE Sebha, 1; El Abiad, 35 (3 skin only; 4 skeletons); Goddua, 15 (9 skull only); Meseguin, 33; Umm el Araneb, 14; Traghen, 12; 6 km N Murzuch, 26; 28 km E Murzuch, 3; Murzuch, 4; 12 km N Ghat, 1; Ghat, 11; El Gatrun, 46; El Barcat, 10.

Measurements. Averages and extremes of 17 adult males and 14 adult females from the vicinity of Sebha are, respectively: Total length 271.4 (261–289), 256.9 (246–277); length of tail 153.8 (143–165), 145.3 (132–155); length of hind foot 33.1 (31–35), 31.9 (30–35); length of ear 16.2 (14–17), 15.3 (14–17); occipitonasal length of skull 34.1 (32.5–35.6), 32.9 (31.8–34.2); length of auditory bulla 11.9 (11.4–12.3), 11.6 (11.2–12.3); crown length of upper molariform toothrow 4.3 (4–4.5), 4.2 (3.9–4.5); greatest breadth across zygomatic arches 17.8 (17.2–18.6), 17.3 (16.7–17.8); least interorbital breadth 6.8 (6.5–7.4), 6.7 (6.3–7.1); breadth of rostrum at level of antorbital foramina 3.5 (3.3–3.8), 3.5 (3.3–3.8); length of nasals 13.4 (12.7–14.3), 12.9 (12.4–13.5).

Diagnosis. Upperparts ranging from Light Ochraceous-Buff to Ochraceous-Buff, becoming paler on sides and flanks; entire dorsum with grayish cast owing to alternate banding on individual hairs; this grayish hue more concentrated in middorsal region; postauricular and supraorbital patches conspicuous and white; rostral, mystacial, circumoral, and scapular areas, and entire underparts pure white; this white extending dorsolaterally beyond the venter and forming an abrupt line where it merges with the buffy color of the dorsum; inner and outer surfaces of pinna of ear sparsely haired and Warm Buff; eye ring black; vibrissae formed from about equal numbers of light and dark hairs; dorsal and ventral surfaces of fore and hind feet densely haired, each with five digits bearing claws; tail relatively long, indistinctly bicolored, Light Ochraceous-Buff above and Pale Ochraceous-Buff below, with prominent pencil (Wood Brown) extending along distal one-third of tail; dorsum of tail with light admixture of brownish hairs. Skull: Large and robust; zygomata heavy; anterior palatine foramina small; post palatine canals narrow and slitlike; braincase flattened; supraorbital bead prominent; auditory bullae narrow transversely and ventrally inflated.

Comparisons. In the shape and proportions of the skull, topotypes of *Gerbillus pyramidum tarabuli* from the vicinity of Sebha, Fezzan Province, Libya, are indistinguishable from specimens of *Gerbillus*

*pyramidum pyramidum* Geoffroy, as known from Giza Province, Egypt. The nominate subspecies is significantly larger, however, in all external and cranial measurements, particularly in the breadth of the zygomatic arches and the length of the nasals. The two subspecies are separable primarily by differences in color, the nominate subspecies being noticeably darker in dorsal color with greater suffusion of dark-colored hairs. Typical *G. p. pyramidum* also have darker and more conspicuously bicolored tails, darker pencils, darker ears, darker and less conspicuous postauricular and supraorbital patches, and darker color around the entire circumorbital area (in many specimens of *G. p. tarabuli*, the suborbital and postauricular patches are almost pure white).

From two specimens (BM, nos. 13.8.6.53 and 13.8.6.60) representing *Gerbillus pyramidum hirtipes* from Ain Sefra, southwestern Algeria, *G. p. tarabuli* is paler and less brilliant in dorsal color, has a longer tail with a more pronounced pencil, and is markedly larger in all other external and cranial measurements.

For comparison with *Gerbillus pyramidum hamadensis*, see account of that subspecies.

Remarks. In the original description, Thomas (1902) used the darker color of *G. p. pyramidum* to separate these two subspecies, but stated that, in the size and proportion of the skull, the two forms were somewhat comparable. Setzer (1957) stated that gerbils representing *G. p. tarabuli* were somewhat smaller but darker in color than those representing *G. p. pyramidum* from the Nile Valley of Egypt. These findings are in partial disagreement with mine, probably because the above comparisons were based on smaller series, as these workers had fewer specimens available at the time. Also Setzer included specimens from Socna and Bir Fergian, Tripolitania Province, within *G. p. tarabuli*. Gerbils from these localities are now known to represent a subspecies distinct from *G. p. tarabuli* and significantly darker in color.

Ellerman and Morrison-Scott (1951) placed *Gerbillus floweri* Thomas in synonymy under *G. p. tarabuli* and thus extended the range of *G. p. tarabuli* to include portions of eastern Egypt and Sinai. Subsequently, Setzer (1958) questioned such a wide distribution for a subspecies and designated *Gerbillus pyramidum floweri* as a separate subspecies based on its lighter color, more inflated auditory bullae, smaller molariform teeth, more laterally curved anterior palatine foramina, and less open pterygoid fossae. It is now known that *G. p. tarabuli* is not part of the mammalian fauna of Egypt but is limited in its distribution to the Libyan Fezzan; in all probability it occurs in

the Saharan Oases and in the vicinity of the Ahaggar Mountains of southeastern Algeria.

Owing to the barriers provided by the Gebel es Soda, Gebel el Harug el Asued, and Hamada de Tinrhert, little, if any, outbreeding takes place with populations of *G. p. hamadensis* to the north and east. The vast Idehan Murzuch and Gebel Ben Ghnema prevent interbreeding with populations of gerbils to the south, so this subspecies has maintained its genetic identity.

Members of this subspecies from El Abiad and Temenhint are darker dorsally than those from nearby Sebha. Specimens from the vicinity of Murzuch, Goddua, Traghen, Umm el Araneb, and Meseguin show an orange-colored dorsal pelage. Animals from Ghat in the extreme southwestern portion of the Fezzan are darker and more variegated in dorsal color, with greater admixture of brownish hairs on the shoulders and rump, and have slightly larger skulls with more bulbous auditory bullae. Examples from El Gatrun, which is located a great distance from the type locality at Sebha, possess almost all the characters typical of *tarabuli*. These specimens, however, are slightly paler in dorsal color and have slightly larger auditory bullae and molariform teeth. Specimens from Brach and Edri in the Wadi es Sciati are more brilliantly colored (Salmon or Orange-Salmon) than any other representatives of this subspecies.

This local variation in color is demonstrable in all populations of this gerbil throughout the Fezzan. In fact, it appears that these gerbils develop different colored pelage depending upon the type of substrate on and in which they live. This widespread variation is suggestive of a broad genetic constitution, which enables these gerbils to respond readily to the variety of conditions imposed by the prevailing environment.

An adult female, no. 322196, from El Gatrun is partially albinistic. This specimen is entirely white except for some brownish hairs on the distal portion of the tail and a faint suffusion of brown on the dorsum.

Ecological observations. These gerbils are the commonest rodents of the Saharan Oases and prefer the sandy areas of the periphery and interior of the oases but also inhabit the vegetated wadis which link the various oases together. They occur sparingly in the margins of the hamadas wherever localized sandy areas are present but apparently do not inhabit the inner portions of these hamadas or the interior of the desolate sand seas.

Their preferred habitat consists of areas of open sand and the numerous small vegetated dunes near the oases proper. Date palms occur in all Saharan oases, and these gerbils are frequently taken from

among the fallen palm fronds and other debris at the bases of the trees. In the Fezzan, they were rarely taken from habitats lacking palm trees.

On several occasions in the larger oases, these gerbils were purchased from local Arabs and presumably had been living in the mud-brick homes of these people. This is the only gerbil in Libya, known to me, which shows commensal tendencies. In their requirements, they are similar to *Gerbillus gerbillus*, but members of the latter species are less abundant and more widely distributed owing to their wider range of ecological tolerances.

Other rodents which occur with *G. p. tarabuli* include *Jaculus jaculus arenaceous*, *Gerbillus amoenus vivax*, and *Acomys cahirinus viator*.

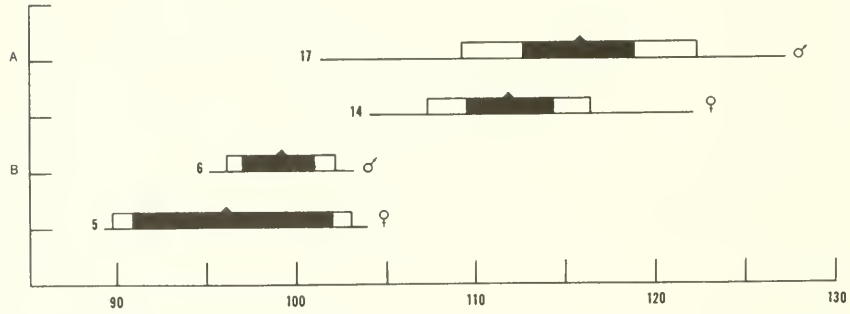


FIGURE 22.—Statistical comparison of length of head and body of the subspecies of *Gerbillus pyramidum:* A, *G. p. tarabuli;* B, *G. p. hamadensis.*

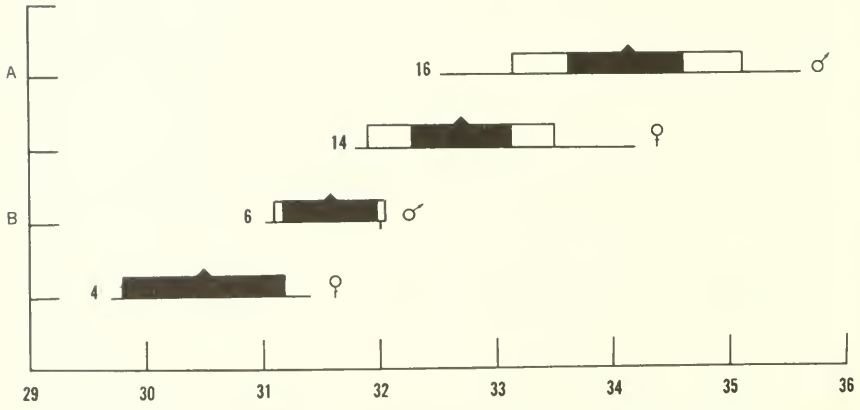


FIGURE 23.—Statistical comparison of occipitonasal length of the subspecies of *Gerbillus pyramidum*. Notation remains the same as in figure 22.

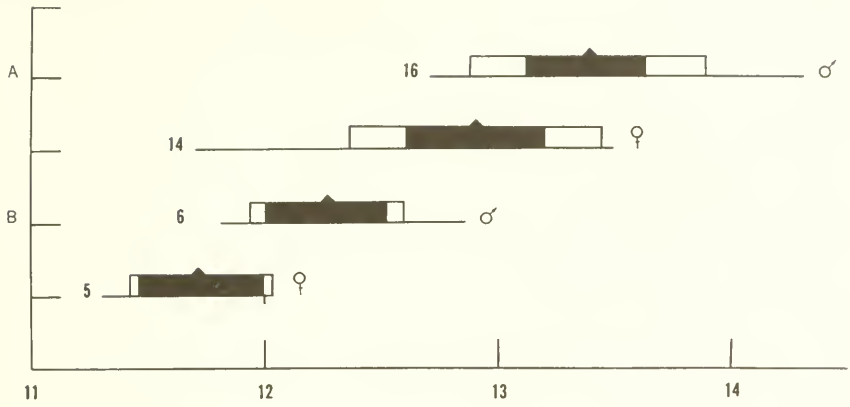


FIGURE 24.—Statistical comparison of length of nasals of the subspecies of *Gerbillus pyramidum*. Notation remains the same as in figure 22.

## Key to the Species of the Subgenus Dipodillus

1. Occipitonasal length less than 23 mm . . . . . **G. henleyi**
   Occipitonasal length more than 23 mm . . . . . 2
2. Tail less than 90 mm; without terminal brush and unicolorous . . **G. kaiseri**
   Tail more than 90 mm; with prominent terminal brush and bicolored . . . 3
3. Occipitonasal length less than 27 mm; auditory bullae large and markedly inflated ventrally, anterior palatine foramina relatively short . **G. amoenus**
   Occipitonasal length more than 27 mm; auditory bullae small and not markedly inflated ventrally; anterior palatine foramina relatively long. **G. campestris**

### *Gerbillus amoenus vivax* (Thomas)

*Dipodillus vivax* Thomas, Proc. Zool. Soc. London, vol. 2, pt. 1, p. 8, October 1902 (Sebha, Fezzan Province, Libya).

GENERAL DISTRIBUTION OF SPECIES. Egypt, Libya, and probably Tunisia, Algeria, and Mauritania.

DISTRIBUTION IN LIBYA. Desert areas of Tripolitania and the Fezzan. In Cyrenaica known from the littoral deserts near the Gulf of Sirte, from Gialo Oasis, and the Gebel el Harug el Asued.

SPECIMENS EXAMINED. Eighty-eight, from CYRENAICA: 5 km W El Agheila, 2; Gialo Oasis, 4; Gebel el Harug el Asued, 200 km SE Zella, 3; from TRIPOLITANIA: 12 km W Zliten, 2; 12 km W Sirte, 1; 2 km SW Hun, 1; 5 km S Socna, 3; from FEZZAN: Edri, 11; El Abiad, 8 (2 skull only); Goddua, 15 (1 skin only, 12 skull only); Meseguin, 2; 6 km N Murzuch, 6; 28 km E Murzuch, 3; 20 km N Ghat, 1; Ghat, 16; El Gatrun, 4; El Barcat, 6.

PUBLISHED RECORDS IN LIBYA. CYRENAICA: Gheminez (Festa, 1921); Augila, Cufra, Gialo (de Beaux, 1932); TRIPOLITANIA: Ain Hammam (Thomas, 1902); El Gheddahia (Toschi, 1951); FEZZAN: Sebha (Thomas, 1902); Ghat (Toschi, 1951).

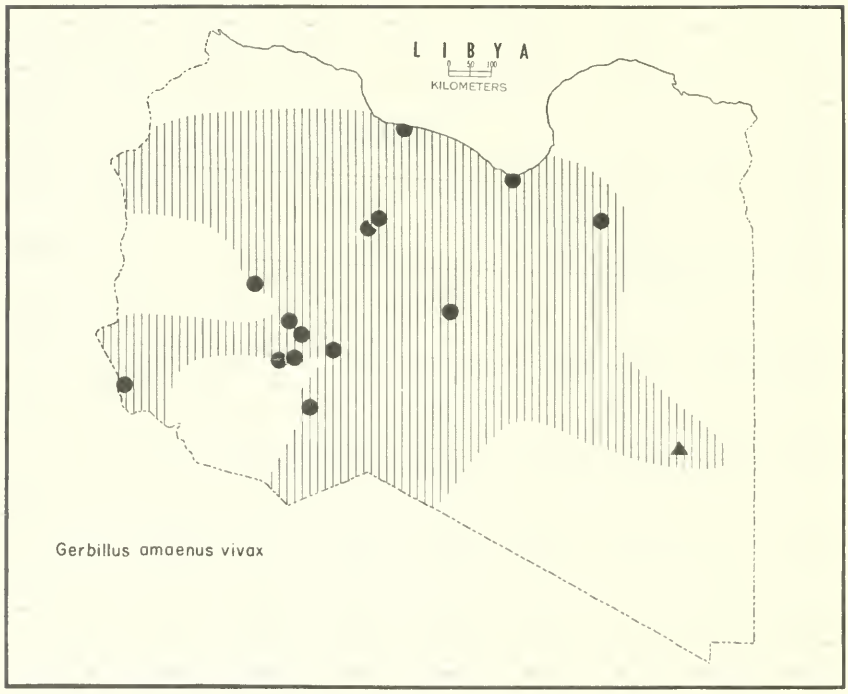


FIGURE 25.—Distribution of *Gerbillus amoenus vivax*. Circles indicate specimens examined; triangle indicates published record.

MEASUREMENTS. Averages and extremes of 10 adult males and the measurements of 3 adult females from Goddua, Fezzan Province, are respectively: Total length 202.2 (187–213), 203, 200, 202; length of tail 112.9 (97–124), 113, 110, 115; length of hind foot 23.2 (22–23), 23, 23, 23; length of ear 12.4 (12–13), 12, 12, 13; occipitonasal length of skull 25.6 (25.2–26.3), 26.8, 25.3, 26.4; length of auditory bulla 9.7 (9.5–10.1), 9.7, 9.6, 9.8; length of upper molariform toothrow 3.3 (3.2–3.4), 3.3, 3.4, 3.4; greatest breadth across zygomatic arches 13.7 (13.4–14.5), 14.5, 13.6, 13.8; least interorbital breadth 4.6 (4.4–4.8), 4.7, 4.3, 4.5; breadth of rostrum at level of antorbital foramina 2.7 (2.5–2.9), 2.9, 2.7, 2.7; length of nasals 9.4 (9.3–9.7), 10.4, 9.4, 10.1.

DIAGNOSIS. Upperparts grading from Cinnamon-Buff to Clay Color, becoming paler on sides owing to suffusion of white; entire dorsum with uniform admixture of brown; plumbeous underfur exposed on dorsum in most specimens; postauricular patches conspicuous and white; pelage around ears and eyes subdued in color, approaching Light Buff, and strongly suffused with gray; a distinct grayish patch (typical of all members of this species) between the base of the pinna

of the ear and eye; rostral and circumoral areas Light Buff; pinna sparsely haired and with small tuft of buffy hairs on anteroventral margin; inner surface of pinna Ochraceous-Buff basally, becoming darker distally and on outer surface approaching Light Grayish Olive; vibrissae relatively short and formed of both light and dark hairs; dorsal surfaces of forelegs, hindlegs, feet, and entire underparts white, the latter, in some specimens, lightly suffused with Buff; fore and hind feet each with five digits bearing claws; palmar and plantar surfaces naked, the latter with six metatarsal tubercles; tail relatively long for the species, sparsely haired with short, hispid hairs, moderately tufted terminally, and in most specimens, distinctly bicolored Hair Brown to Wood Brown dorsally and ranging from Light Buff to almost white ventrally; the dorsum of the tail appears particolored owing to the interspersion of light and dark hairs and to exposure of the pale ground color from beneath; this variegated character of the tail is typical. Skull: Relatively large and robust; auditory bullae markedly large, bulbous and inflated ventrally; basioccipital narrow and rod-shaped anteriorly, thus forming distinct elliptical posterior lacerated foramina between it and the auditory bullae; anterior palatine foramina short and rectangular; zygomata relatively heavy with tendency to bow outward posteriorly; braincase moderately domed.

Comparisons. Near topotypes of *Gerbillus amoenus vivax* from Goddua, Fezzan Province, Libya, differ from two topotypes of *Gerbillus amoenus amoenus* (de Winton) from El Aiyat, Mit Riheina, Giza Province, Egypt, in having larger and more robust skulls, noticeably larger, more bulbous and more ventrally inflated auditory bullae, heavier zygomata, wider zygomatic breadth, slightly larger molariform teeth, and longer nasals. Specimens from Libya are also paler in dorsal color, larger in total length, and have longer and slightly more tufted tails.

Cranially, representatives of *G. a. amoenus* from Wadi Natroun, Western Desert Governorate, Egypt, are appreciably larger than the two topotypes from Giza Province and are comparable to specimens of *G. a. vivax* but differ in having shorter and less tufted tails and markedly smaller and less inflated auditory bullae. Another large series of *G. a. amoenus* from near Faiyum, Egypt, has the smallest auditory bullae of any of the specimens examined from Egypt and, in this character alone, can easily be distinguished from those of *G. a. vivax* from Libya.

This subspecies resembles *Gerbillus nanus nanus* Blanford from Kerman Province, Iran but can be distinguished from the latter by much shorter tail, lighter (less grayish) dorsal color, smaller cranial size, noticeably smaller anterior palatine foramina, and markedly smaller and less inflated auditory bullae.

From a single specimen of *Gerbillus mackilligini* (Thomas) from Wadi Kansisrob, Sudan Government Administrative Area, Egypt, specimens of *G. a. vivax* are noticeably smaller in overall size, more variegated in dorsal color, and have shorter, more particolored and less tufted tails, smaller hind feet, smaller and less inflated auditory bullae, shorter anterior palatine foramina and posterior palatine canals, less expanded braincases, and are smaller in all measurable cranial characters.

Compared to *Gerbillus campestris dodsoni*, *G. a. vivax* is much smaller cranially and in overall size, has a noticeably shorter and less tufted tail, considerably larger and more inflated auditory bullae, and much shorter anterior palatine foramina.

Remarks. Originally, Thomas (1902, p. 8) described *Dipodillus vivax* from Sebha, Fezzan Province, Libya, and stated that it was closely related to *Dipodillus quadrimaculatus* Bodenheimer and *Dipodillus amoenus* de Winton of the *D. quadrimaculatus* group of Egypt but differed from both by its decidely larger auditory bullae, narrower basioccipital, and more uniform "ochraceous buffy" color. He thus considered *D. vivax* as distinct from *D. amoenus* and regarded *D. vivax* as the Tripolitanian representative of the *quadrimaculatus* group of Egypt.

Later, Ellerman and Morrison-Scott (1951), Toschi (1954), and Setzer (1957) regarded *D. amoenus* and *D. vivax* as conspecific but included them as subspecies of *Gerbillus dasyurus* (Wagner), whose range had previously been limited to Sinai and areas to the north and east. The above workers had only a few specimens, and their assignments probably were based largely upon geographic grounds. In the present study, large series of topotypical *G. dasyurus* from Sinai and *G. amoenus* from Egypt are available; the two groups were more critically compared, and the following differences are noted: Specimens of *G. dasyurus* are significantly larger in all cranial and external measurements, have longer, denser, and more lustrous fur, appear more variegated dorsally, and have longer and noticeably more tufted tails, more inflated braincases, relatively narrower rostra, longer and more slitlike anterior palatine foramina and wider basioccipitals. It is evident that *G. amoenus* is a species distinct from *G. dasyurus* and that the latter is confined, as was previously thought, to areas east of the Nile River.

Toschi (1954) assigned specimens from Gheminez to *G. dasyurus amoenus* (=*G. amoenus amoenus*) and those from other widely scattered localities, including Cufra Oasis, to *G. dasyurus vivax* (=*G. a. vivax*). Setzer (1957), with reservations, included the few specimens available to him within the subspecies *G. a. vivax* and did not recognize the nominate subspecies as occurring in Libya.

Wassif (1956), in reviewing the dipodils of Egypt, recognized that gerbils representing *G. amoenus* and *G. dasyurus* were not of the same species and reinstated the former as a full species with a range confined to Egypt west of the Nile. He predicted that specimens from Tripolitania and other localities in Libya also probably represented a variety of *G. amoenus*. The present author is in agreement with Wassif in considering *G. amoenus* as a full species, and *G. dasyurus* is no longer considered as a part of the Libyan mammalian fauna.

Specimens from the Fezzan are slightly larger in size of body, and their skulls have slightly larger and more inflated auditory bullae than those from Tripolitania and Cyrenaica. Within the Fezzan, the various populations are remarkably similar in cranial and external characters. Specimens from El Gatrun are slightly larger than topotypical specimens from near Sebha, and a large series from Ghat and El Barcat are correspondingly smaller. To the north in Tripolitania, specimens from Zliten and Socna are comparable in size to typical *G. a. vivax* but have somewhat smaller auditory bullae. Specimens from farther east in Cyrenaica and nearer the type locality of *G. a. amoenus* are appreciably smaller in size and possess the smallest auditory bullae of any representatives of this subspecies in Libya. This diminution in bullar size in these easternmost populations of gerbils suggests intergradation with *G. a. amoenus*. A gradient, extending from west to east and showing progressive decrease in size and degree of inflation of the auditory bullae, is apparent in populations of this gerbil in Libya and Egypt. Gerbils with small auditory bullae from the Nile Delta thus represent the easternmost limits of expression of this character, and those with larger auditory bullae from the Fezzan are near the westernmost limits of this character gradient. It appears that the subspecies *G. a. amoenus* and *G. a. vivax* actually represent the two extremes in this clinal gradient. It is not uncommon for populations at each end of a cline to develop dissimilarities of sufficient magnitude to warrant designation as distinct subspecies, especially when the clinal character extends over such a wide geographic area.

While recognizing that the foregoing variation and clinal pattern exists within and between populations of this gerbil in Libya, and even though the easternmost populations show some characters typical of *G. a. amoenus*, I prefer to assign all of the specimens from Libya to *G. a. vivax*.

Four specimens from Biskra and a single specimen from Beni Abbes, Algeria, are within the geographic range ascribed to *Gerbillus garamantis* (Lataste). In cranial characters, these specimens are strikingly similar to those of *G. a. vivax* from western Tripolitania and the Fezzan. In cranial measurements, however, gerbils from Libya,

including near topotypes of *G. a. vivax* from Goddua, Fezzan, are slightly smaller in length of skull and have slightly shorter nasals and anterior palatine foramina. The length of the skull of the type specimen of *G. garamantis*, as given by Lataste (1881), is also larger than typical *G. a. vivax*. Gerbils from both countries agree closely in external measurements, except for the slightly longer tail in those from Libya. In color, the populations are almost identical, but specimens from Algeria have longer, more lustrous, silkier fur. This character is particularly striking in the specimen from Beni Abbes. The specimens from Biskra differ in having appreciably longer and more inflated auditory bullae. The foregoing differences are not of sufficient magnitude to distinguish species but are more typical of the subtle characters used to distinguish populations at the infraspecific level. Furthermore, the enlarged auditory bullae of the specimens from Biskra probably represent an extension of the east-west cline apparent in populations of *G. a. amoenus* and *G. a. vivax* to the east.

When the Algerian populations have been studied more thoroughly and topotypical material from Ouargla becomes available for comparison, these gerbils in Algeria and Libya, which are currently known as *G. garamantis* and *G. amoenus*, respectively, probably will be regarded as conspecific and differ only as subspecies. Because of priority, the current *G. amoenus* will become a synonym of *G. garamantis* or be relegated to subspecific rank under the latter.

When Lataste named *G. garamantis* in 1881, *Dipodillus campestris* (=*Gerbillus campestris*) and *Gerbillus simoni* Lataste were the only North African gerbils known within the dipodil group. Comparative specimens were largely unavailable from Libya and Egypt, and at that time, these Algerian specimens were clearly distinct from all others available to him. Ellerman and Morrison-Scott (1951) included *G. garamantis* as a subspecies of *Gerbillus nanus* and thus extended the range of the species far westward along North Africa. These Algerian populations were several thousand miles distant from the nearest representatives of *G. nanus* east of the Nile River. The above authors offered no explanation for this great hiatus in distribution of members of the same species. Setzer (1952) assigned three specimens from Kom Aushim, Giza Province, Egypt, to *Gerbillus nanus garamantis* but thought it unlikely that gerbils from the Nile Valley and Algeria belonged to the same subspecies. Wassif (1956) referred these specimens from Kom Aushim to *G. a. amoenus* and suspected that *G. nanus* did not occur in Egypt. The present study indicates that *G. nanus* is also not present in the mammalian fauna of Libya.

Ecological observations. These dipodils occur in virtually all types of habitats in Libya. Specimens obtained at Ghat, Edri, El Gatrun, Meseguin, and near Murzuch came from areas of loose sand

covered by fallen fronds at the bases of date palms. At Goddua this species was taken from the loose sand of the palm groves and the sandy-clay soils of other agricultural areas within the oasis. The specimens from the Gebel el Harug el Asued were collected from rather impervious clay soils in a badly eroded large wadi. At other localities in Libya these gerbils were obtained in habitats ranging from the dense plant cover of the coastal plain to almost barren hamadas. They seem to prefer areas of loose sand or substrates of a sandy character; only rarely are they found in large, permanent dune areas.

The collection of specimens of this species was fortuitous, and their presence in a given area could never be predicted with certainty. Adequate series were obtained only after several days of continuous trapping.

In many areas in Libya, members of this species occur sympatrically with those of other species of gerbils, but they are almost always less abundant.

### *Gerbillus campestris* Levaillant

*Gerbillus campestris* Levaillant, Atlas Expl. Sci. Alg. Mamm. pl. V, fig. 2., 1857 (Philippeville, Province of Constantine, Algeria [Lataste, 1881]).

General distribution of species. Western and coastal Egypt; Libya, Algeria, Morocco; range probably also includes northern portions of Sudan, Chad, Niger, and Mauritania.

Distribution in Libya. Widespread throughout Cyrenaica, Tripolitania, and the Fezzan (currently unknown from Gialo Oasis).

Distribution of the subspecies in Libya.

*Gerbillus campestris brunnescens.* Cyrenaica: Cyrenaican Plateau and adjacent Mediterranean littoral.

*Gerbillus campestris dodsoni.* Cyrenaica, Tripolitania, and the Fezzan: Widespread throughout Tripolitania and the Fezzan, but in Cyrenaica is limited to the southern oases of Tazerbo and Bzema.

*Gerbillus campestris haymani.* Cyrenaica: Vicinity of Giarabub and Bahr el Tubat.

*Gerbillus campestris patrizii.* Cyrenaica: El Hauuari and El Giof of Cufra Oasis.

*Gerbillus campestris wassifi.* Cyrenaica: Coastal plain of extreme northeastern Cyrenaica.

Published records in Libya. Cyrenaica: Giarabub (de Beaux, 1928); El Giof (de Beaux, 1932); Tripolitania: Wadi Agarib, Ain Hammam, Wadi Nefed, Sirte, Tamari-Ferdjan (Thomas, 1902); Fezzan: Goddua, Umm el Abid (Thomas, 1902).

Comparisons. *Gerbillus campestris* can be distinguished readily from the other dipodils in Libya by its much larger size, longer anterior palatine foramina, and markedly smaller and less inflated auditory bullae.

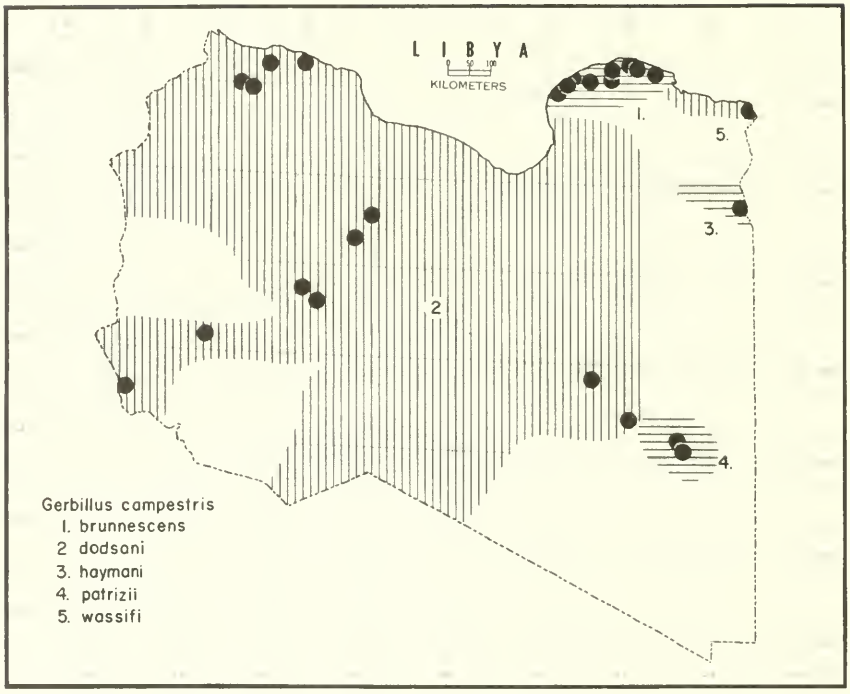


FIGURE 26.—Distribution of the subspecies of *Gerbillus campestris*.

REMARKS. Setzer (1957) referred all specimens of this gerbil from Libya to *Gerbillus campestris dodsoni*. *Gerbillus campestris patrizii* from Cufra Oasis was placed in synonymy under *G. c. dodsoni*, and specimens from the Cyrenaican Plateau were likewise included with this subspecies. In a later paper, Setzer (1958) described *G. c. wassifi* (p. 208) from the Egyptian littoral and *G. c. haymani* (p. 209) from Siwa Oasis of western Egypt. Both of these type localities are located near the Libyan frontier. Currently, many more localities in Libya are represented by specimens, and the taxonomic relationships can be investigated more thoroughly. Gerbils from the coastal plain of northern Cyrenaica are referable to *G. c. wassifi*, and those from Bahr el Tubat, near Giarabub, represent *G. c. haymani*. The specimens from the Cyrenaican Plateau, formerly referred to *G. c. dodsoni* by Setzer, have been supplemented with additional series from the nearby coastal plain and are here recognized as a new subspecies, *G. c. brunnescens*, distinct from *dodsoni*. Furthermore, *G. c. patrizii* has been reinstated as a subspecies based upon the critical examination of newly acquired specimens from El Hauuari and El Giof of Cufra Oasis. The range of *G. c. dodsoni* is extended to include all of Tripolitania, most

of the Fezzan, and a large portion of southern Cyrenaica. As a result of the present study, five subspecies of *G. c. campestris* are now known to occur in Libya.

Ecological observations. Members of this species are the most widely distributed of all Libyan rodents and occur in virtually all habitats. In the larger oases where sandy areas and date palms are widespread, gerbils belonging to the subgenus *Gerbillus* are more abundant, and representatives of *G. campestris* are confined more to the mesic habitats of the sedge pockets in the interior of the palm groves or occur beyond the oasis proper in the zone of tamarix and acacia. Apparently, *G. campestris* is not able to compete with these sand-loving gerbils and is forced to inhabit these marginal habitats. In a few cases, however, these gerbils occupied all habitats within the oasis. Rocky areas appear to be preferred above all others; wherever cliffs, rocky outcroppings, or talus are present, these rodents occur in abundance.

***Gerbillus campestris brunnescens*, new subspecies**

Holotype. Adult male, skin and skull, USNM 302180, from 5 km SE Derna, Cyrenaica Province, Libya; obtained Nov. 9, 1955, by H. W. Setzer, original no. 2724.

Specimens examined. One hundred twenty-one, from Cyrenaica: 27 km E Apollonia, 3; 11 km SW Susa (=Apollonia), 5; 12 km SW Apollonia, 2 (1 skin only); 12 km S Apollonia, 2; 5 km NW Labrag, 6 (1 skin only); 4 km W Labrag, 1; 12 km NW Gubba 3 (1 skin only); 3 km E Derna, 8; 5 km SE Derna, 27 (1 skin only); Wadi el Kuf, 13 km WSW Messa, 7; 10 km SW El Faidia, 6; 7 km NE Slonta, 1; 5 km W Tocra, 29 (1 skin only); 20 km SW Tocra, 16; 10 km N Gerdes, 3; 2 km N Coefia, 2.

Measurements. Averages and extremes of 15 males and 9 females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 244.8 (228–262), 236 (223–252), [248]; length of tail 143.1 (132–150), 137.8 (127–152), [148]; length of hind foot 28.2 (27–30), 27.3 (27–28), [28]; length of ear 17.6 (17–19), 17.2 (17–18), [18]; occipitonasal length of skull 30.3 (28.9–31.6), 29.5 (28.9–30.2) [30.2]; length of auditory bulla 9.3 (8.9–9.7), 9.3 (9–9.5), [9.3]; crown length of upper molariform toothrow 3.9 (3.8–4.1), 4 (3.9–4.2), [3.9]; greatest breadth across zygomatic arches 15.6 (14.7–16.6), 14.9 (14.4–15.2), [15.5]; least interorbital breadth 5.5 (5.2–5.9), 5.4 (5.2–5.7), [5.7]; breadth of rostrum at level of antorbital foramina 3.2 (3.1–3.4), 3.2 (3.1–3.3), [3.3]; greatest length of nasals 11.6 (11–12.8), 11.3 (10.9–11.7), [11.2].

Diagnosis. Upperparts Sudan Brown becoming paler on sides and scapular areas; all parts of dorsum with strong suffusion of blackish-

brown hairs, being particularly concentrated on rump; subauricular region with strong admixture of blackish hairs; preauricular and postauricular patches conspicuous and white; eye ring black; mystacial, circumoral, and pectoral areas Light Buff; pinna of ear sparsely haired, Ochraceous-Tawny basally and Mummy Brown distally, and with distinct tuft of grayish hairs on anteroventral margin; vibrissae relatively short and formed from equal numbers of light and dark hairs; forearm with distinct buffy patch and otherwise white throughout; hindlegs with conspicuous Dark Olive patch on ventral surface, otherwise white throughout; fore and hind feet white, each bearing five digits with claws; palmar and plantar surfaces of fore and hind feet entirely naked, the latter Mars Brown in color; underfur of all dorsal pelage Deep Plumbeous; entire underparts white with faint buffy suffusion in some specimens; tail relatively long, distinctly bicolored, Verona Brown dorsally, almost white ventrally and slightly penicillate. Skull: Small and gracile; auditory bullae small and mildly inflated ventrally; zygomatic breadth narrow and zygomata fragile; braincase slightly vaulted.

Comparisons. Compared with a single specimen of *Gerbillus campestris campestris* from near Oran, Algeria, the type and paratypes of *Gerbillus compestris brunnescens* are paler in dorsal color, have slightly more tufted tails, much longer tails, more suffusion of dark color around eyes, larger bodies, and cranially are larger and more robust, with wider rostra, wider interorbital breadths, and larger cranial measurements, especially length of the upper molariform toothrow.

Members of this new subspecies may be distinguished from topotypes of *G. c. dodsoni* from Ain Hammam, Tripolitania Province, and a large series from Brach, Fezzan Province, by their darker (more brownish) and more uniform dorsal color, longer and markedly less tufted tails, greater overall length of body, slightly shorter ears, less robust skulls, markedly smaller and less inflated auditory bullae, and more vaulted braincases.

Compared with topotypical *G. c. haymani* from Siwa Oasis, Western Desert Governorate, Egypt, and a small series representing *haymani* from Bahr el Tubat, Cyrenaica Province, Libya, *G. c. brunnescens* is markedly darker in dorsal coloration, has a less tufted tail, smaller hind feet and ears, and a more gracile skull which is markedly smaller in all cranial characters, being closest in the width of the rostrum and the length of the upper molariform toothrow.

From topotypes of *G. c. wassifi* from the Libyan Plateau, near Salum, Western Desert Governorate, Egypt, *G. c. brunnescens* differs in its darker dorsal color, smaller overall size, relatively longer tail, smaller ears, smaller skull, narrower anterior palatine foramina, narrower

zygomatic breadth, shorter nasals, and shorter and less inflated auditory bullae.

This new subspecies can be readily distinguished from *Gerbillus campestris patrizii* by its darker, more uniform dorsal coloration and noticeably larger size of body and cranium, being comparable only in length of the auditory bullae and length of upper molariform toothrow.

Remarks. Members of this subspecies can be distinguished from all others in Libya by their darker, more uniform dorsal color and somewhat longer and less tufted tails. Setzer (1957) assigned specimens from the Cyrenaican Plateau to *G. c. dodsoni*. His assignment was based solely upon some notes characterizing the type specimen of *G. c. dodsoni* in the British Museum and upon favorable comparison with the original description of *Dipodillus dodsoni* as given by Thomas (1902). In the present study, more specimens are available from the Cyrenaican Plateau, and topotypes of *dodsoni*, in addition to large series from various other localities in Libya, are on hand. Thus, the taxonomic status of these specimens from the Cyrenaican Plateau can be determined more accurately.

The range of this subspecies is confined to the uplands of the Cyrenaican Plateau and the adjacent littoral areas. Intergradation between *G. c. brunnescens* and *G. c. wassifi* of extreme northeastern Cyrenaica and coastal Egypt is apparent in specimens from the coastal areas near Derna and Apollonia. In their pale dorsal color, large cranial size, and wide anterior palatine foramina, they resemble *G. c. wassifi*, but in the size and degree of inflation of the auditory bullae and in all other cranial characters, they are closer to *G. c. brunnescens* and are assigned to this subspecies. The vast areas of central Cyrenaica, including Gialo Oasis and the Gebel el Harug el Asued, and the littoral deserts and coastal plain along the Gulf of Sirte are not represented by specimens and thus create a decided gap in distribution. The two specimens from near Coefia, representing the southernmost record of distribution for *G. c. brunnescens*, show no evidences of gene exchange with *G. c. dodsoni*, whose range is farther to the south and west.

Within populations of this subspecies in Cyrenaica, local variation in dorsal color is apparent. The pattern of this color gradient is too irregular to suggest clinal variation and probably a genetic response to the local character of the substrate. Gerbils from the coastal plain, where the soils are darker, tend to be darker and more uniform in dorsal color than those from the plateau. This dark dorsal color reaches its extreme in specimens from the vicinity of Tocra.

Ecological observations. These rodents are the most abundant gerbils in the Cyrenaican Plateau and were regularly taken in traplines. Other dipodils were collected on the plateau, but they were fewer in number. Members of this subspecies occupy almost all of the

available habitats on the plateau and coastal plain ranging from the exposed uplands with a scanty vegetative cover to the dense plant cover of the larger wadis. They are perhaps most abundant in the chaparral vegetation of the hillsides and throughout the dense vegetation of the coastal plain. They also occupy the rocky cliffs and talus of the wadis and the rocky outcroppings along the coastal escarpments. They were never collected from coastal dunes or other habitats composed exclusively of sand. In these habitats they are supplanted by the more sand-loving *Gerbillus eatoni*.

The name *brunnescens*, meaning dark, dusky, or brown, alludes to the brownish color of the dorsal pelage of members of this subspecies.

***Gerbillus campestris dodsoni* (Thomas)**

*Dipodillus dodsoni* Thomas, Proc. Zool. Soc. London, vol. 2, pt. 1, p. 7, October 1902 (Ain Hammam, Tripolitania Province, Libya).

Specimens examined. One hundred thirty-seven, from Cyrenaica: Tazerbo Oasis, 44; El Gezira (Tazerbo Oasis), 15; Bzema Oasis, 9 (1 skin only); from Tripolitania: 5 km W Cussabat, 6; 20 km N Gharian, 3; 20 km E Rumia, 2; 12 km S Chicla, 2; Ain Hammam, 3 (BM); Gebel es Soda, 60 km S Socna, 4; from Fezzan: Brach, 31; Temenhint, 2 (1 skull only); 75 km W Ubari, 2; 20 km N Ghat, 1; Ghat, 1.

Measurements. Averages and extremes of 17 adult males and 21 adult females from Tazerbo Oasis, Cyrenaica Province, are, respectively: Total length 223.1 (205–238), 222.9 (211–254); length of tail 126.6 (118–140), 127.9 (111–148); length of hind foot 26.9 (25–29), 26.7 (25–28); length of ear 16 (15–17), 15.7 (14–17); occipitonasal length of skull 30.4 (28.6–31.7), 30.5 (28.7–32.1); length of auditory bulla 9.7 (9.2–10.1), 9.7 (9.2–10.1); crown length of upper molariform toothrow 3.9 (3.7–4.2), 4 (3.8–4.3); greatest breadth across zygomatic arches 15.8 (14.6–16.5), 16 (15.1–16.5); least interorbital breadth 5.5 (5–6), 5.4 (4.7–6); breadth of rostrum at level of antorbital foramina 3.2 (3–3.4), 3.2 (3–3.4); length of nasals 11.9 (10.6–12.6), 11.4 (11–13).

Diagnosis. Dorsal color ranging from Cinnamon-Brown, Sudan Brown, and Verona Brown to Ochraceous-Tawny, all frequently occurring in animals of the same local population; most specimens with strong suffusions of darker hairs on dorsum, resulting in a variegated or marbled appearance; other specimens uniformly colored; in most specimens postauricular patches indistinct and suffused with buffy hairs, and in others almost white; circumorbital areas generally Light Buff with admixture of brownish hairs, in some specimens darker and approaching color of dorsum; eye ring black; scapular regions heavily suffused with brownish or buffy hairs, which

sometimes extend to forearm; vibrissae relatively long and longer hairs dark brown and lighter ones usually white; pinnae of ears sparsely haired, becoming darker distally, ranging in color from Drab to Fuscous; circumoral areas, dorsal surfaces of forelegs, hindlegs, feet, entire underparts and, in some specimens, ventral surface of tail pure white; fore and hind feet with five digits bearing claws; palmar and plantar surfaces naked, the latter with six metatarsal tubercles; tail medium in length with distal one-third forming prominent brownish pencil; tail usually conspicuously bicolored varying from almost pure white to Avellaneous ventrally and from Sayal Brown to Warm Sepia dorsally; this bicoloration less striking in darker specimens. Skull: Medium in size; frontal bone with a distinct fossa near the nasofrontal suture; zygomata strong and bowing outward posteriorly; braincase flattened; auditory bullae noticeably large and bulbous.

Comparisons. Compared to a single adult specimen of *Gerbillus campestris campestris* from near Oran, Algeria, specimens from Brach, Fezzan Province, and Tazerbo Oasis, Cyrenaica Province, are larger in overall size, have markedly longer and more terminally tufted tails, darker, more variable, variegated dorsal color, longer vibrissae, and larger measurable cranial characters.

In dorsal color, these same specimens resemble topotypes of *Gerbillus campestris rozsikae* Thomas from Biskra, Algeria but differ from this subspecies in being larger in size of body and cranium and having longer, more conspicuously tufted tails, shorter anterior palatine foramina, and larger, more ventrally inflated auditory bullae.

For comparisons of these gerbils from Brach and Tazerbo Oases with *Gerbillus campestris brunnescens*, *G. c. wassifi*, *G. c. haymani*, and *G. c. patrizii*, see accounts of those subspecies.

Remarks. These specimens from Tazerbo and Brach, although clearly referable to *G. c. dodsoni*, differ from topotypes of the latter from Ain Hammam, Tripolitania Province, in having slightly darker dorsal coloration, more tufted tails, larger auditory bullae, wider rostra, and slightly wider interorbital region. Other representatives from various localities throughout Cyrenaica, Tripolitania, and the Fezzan also differ from topotypical *G. c. dodsoni* in subtle characters. These tenuous differences, however, do not exceed the variation expected within populations of the same subspecies.

In 1902, Thomas described *Dipodillus dodsoni* (=*Gerbillus campestris dodsoni*) from Ain Hammam, Tripolitania Province, Libya, as distinct from *Dipodillus campestris* of the coastal areas of Algeria. The two species were distinguished by the larger size, more "desert colour," and more prominently tufted tail of *D. dodsoni*. He assigned specimens, now known as *Gerbillus campestris rozsikae*, from Biskra,

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Algeria, to *D. dodsoni* and included all of Tripolitania and portions of the Fezzan within the range of *D. dodsoni*. The present work indicates that the range of *G. c. dodsoni* is confined to western and central Libya and perhaps includes portions of eastern Algeria and Tunisia.

Gerbils from the Gebel es Soda and the Gebel Nefusa are paler in dorsal color and have larger, more inflated auditory bullae than those from other localities in Tripolitania. Representatives of this subspecies from near Cussabat are darker in dorsal color and have less tufted tails than those of populations to the south. Specimens from near Ghat, Temenhint, and Ubari, in the Fezzan, have markedly more tufted tails (sometimes the pencil occupies one-half the total length of the tail), less streaked dorsal pelage, slightly larger auditory bullae, and are slightly larger in general size than those from Brach farther north. Except for slightly larger auditory bullae in gerbils from the Fezzan, those from Tazerbo Oasis in Cyrenaica and from Brach in the Fezzan, although widely separated geographically, are indistinguishable in color and cranial characteristics. All of the specimens here assigned to *G. c. dodsoni* possess prominently tufted tails and have large, inflated auditory bullae, which are the most diagnostic characters of this subspecies.

No specimens of *G. campestris* are available from the oasis of Gialo, but because this species is widespread to the north and occurs abundantly in the remote oases farther to the south in Cyrenaica, probably they occur here also. Gialo is located between the ranges of *G. c. brunnescens* and *G. c. dodsoni*, and when specimens of *G. campestris* become available from Gialo, they may possess characters of both subspecies.

With the exception of the large series from Brach, only six additional specimens of this subspecies were obtained from the Fezzan. These few specimens do not provide a reliable index to their actual numbers. Suitable habitat is of widespread occurrence throughout the various wadis, serirs, and oases of the Fezzan, and any barriers to dispersal are of local extent. It is probable that these gerbils occur in all the major oases in the Fezzan and also those of southern and central Cyrenaica. This species has not been recorded from the Tibesti Mountains but probably occurs there.

Evidences of gene exchange with other subspecies are lacking, probably owing to the largely disjunct distribution of this subspecies and also to the lack of specimens from most of the marginal areas; hence, comparisons are not possible. Intergradation with *G. c. brunnescens* probably takes place somewhere along the littoral areas of the Gulf of Sirte, and gene exchange with *G. c. rozsikae* and the nominate subspecies may take place somewhere among populations

of these gerbils in eastern Tunisia and Algeria. Members of this subspecies have no physical contact with those of *G. c. wassifi* of the Mediterranean littoral, and it is doubtful if gene flow is a common occurrence between animals of *G. c. dodsoni* and *G. c. haymani*, whose range includes the isolated depressions and the oases of Giarabub and Siwa far to the east.

Ecological observations. In the Gebel Nefusa, these gerbils inhabit the crevices and fissures of the rocky outcroppings along canyons that descend onto the coastal plain. Those from the Gebel es Soda were taken among the coarse extrusions of volcanic material near the highest point of the gebel. The large series from Brach was obtained from moist areas supporting dense growths of sedges and grasses associated with agriculture. At Temenhint Oasis, two specimens were obtained from the sand surrounding date palms. Near Ubari, two additional specimens were obtained from the practically denuded margins of a shallow wadi which supported sparse growths of acacia and occasional dried grasses. Near Ghat the habitat was typical "hamada" desert without any visible plant cover.

At the oases of Bzema and Tazerbo, these gerbils occur abundantly in the dense pockets of sedges that occupy the low-lying interior portions of the palm groves. In fact, at Tazerbo, trap yields exceeded 85 percent and were the highest recorded for Libya.

A specimen from Tazerbo Oasis, an adult male, 325387, is strikingly different in color from other specimens from this locality. It is uniformly gray throughout except for the tail, which is strongly suffused with brown.

One specimen, an adult female, 325403, from Bzema Oasis is heavily suffused with white on the dorsum, the tail has uniform admixtures of white hairs throughout, and the ears and feet are extremely pale. This specimen is the only example of albinism or partial albinism observed in this species.

### *Gerbillus campestris haymani* Setzer

*Gerbillus campestris haymani* Setzer, Journ. Egypt. Publ. Health Assoc., vol. 33, no. 6, pp. 208–209, 1958 (Siwa Oasis, Western Desert Governorate, Egypt).

Specimens examined. Four, from Bahr el Tubat, Cyrenaica Province, Libya.

Measurements. Measurements of two adult males, 325501 and 325502, and two adult females, 325503 and 325504, from the above locality are, respectively: Total length 268, 240, 239, 241; length of tail 160, 141, 136, 140; length of hind foot 29, 30, 27, 28; length of ear 17, 17, 17, 17; occipitonasal length of skull 32, 31.2, 31.5, 31.5; length of auditory bulla 10.3, 9.8, 10, 10.1; length of upper molariform toothrow 3.9, 3.8, 4.2, 4.2; greatest breadth across zygomatic

arches 16, 16.4, 16.5, 16; least interorbital breadth 5.6, 5.4, 5.9, 5.5; breadth of rostrum at level of antorbital foramina 3.1, 3.1, 3.4, 3.3; length of nasals 12.6, 13.2, 12.5, 12.5.

Diagnosis. Middorsal region Clay Color to Tawny-Olive, becoming paler on sides and flanks and approaching Cinnamon-Buff; entire dorsum with uniform suffusion of brown hairs; circumorbital areas Pale Pinkish Buff, strongly suffused with black hairs; postauricular patches Pale Pinkish Buff; circumoral area, dorsal surfaces of fore and hind feet and legs, and entire underparts white; upper arms with indistinct buffy patch; fore and hind feet each with five digits bearing claws; palmar and plantar surfaces of feet entirely naked, the latter with six metatarsal tubercles; vibrissae relatively long with equal numbers of white and brown hairs; pinnae of ears sparsely haired Ochraceous-Buff basally and Hair Brown distally; tail relatively long and indistinctly bicolored, being somewhat darker dorsally with greater suffusion of brown hairs and with inconspicuous Drab pencil. Skull: Large and robust; zygomata heavy; braincase flattened; auditory bullae large; supraorbital ridges poorly defined; nasals long; and rostrum wide.

Comparisons. From topotypes of *Gerbillus campestris dodsoni* from Ain Hammam, Tripolitania Province, Libya, and representatives of *G. c. dodsoni* from Tazerbo Oasis, Cyrenaica Province, specimens from Bahr el Tubat are paler and more uniform in dorsal color; have longer, less bicolored, and less tufted tails; proportionately smaller and less inflated auditory bullae; and are larger in all measurements.

Compared to topotypes of *Gerbillus campestris haymani* from Siwa Oasis, Egypt, specimens from Bahr el Tubat, Cyrenaica Province, have slightly longer tails, smaller ears, slightly shorter molariform teeth, and narrower zygomatic arches. These subtle differences, however, fall well within the range of variation for members of *G. c. haymani*, and because these specimens from Bahr el Tubat are much larger cranially and in body size from all other contiguous subspecies, they are clearly referable to *G. c. haymani*.

For comparisons with *G. c. brunnescens*, *G. c. patrizii*, and *G. c. wassifi*, see accounts of those subspecies.

Remarks. Hayman (1949), somewhat dubiously, referred specimens from Siwa Oasis in western Egypt to *Dipodillus dodsoni* but recognized that these specimens differed from typical representatives of *Dipodillus dodsoni* from Tripolitania Province in having slightly paler and less rufous tails with slaty rather than brownish pencils. Ellerman and Morrison-Scott (1951) assigned these same specimens to *Gerbillus campestris campestris* and suggested that *D. dodsoni* was probably a synonym of *G. c. campestris* and thus extended the range of the nominate subspecies to include most of coastal and interior Libya and

a portion of western Egypt. Later, Wassif (1956) recognized that these gerbils from Siwa Oasis were distinct from those of the Mediterranean littoral and assigned the coastal population to *G. c. campestris* and those of the interior to *G. c. dodsoni*. Setzer (1958) concluded that the gerbils from Siwa Oasis and those from the coastal areas were distinct from each other and from both *G. c. dodsoni* and *G. c. campestris;* accordingly, as new subspecies, he described the interior population as *G. c. haymani* and the coastal population as *G. c. wassifi*.

It is now known that *G. c. haymani* represents a subspecies which can be distinguished from all other subspecies of *Gerbillus campestris* by its larger size, and its range is limited to the low-lying, sandy depressions surrounding Bahr el Tubat and Siwa Oasis. When specimens become available from Giarabub Oasis in Cyrenaica Province, Libya, and the Qattara Depression of Egypt, they probably also will be referable to *G. c. haymani*.

This small series was taken in the midst of an extensive growth of *Phragmites* adjacent to the large saline lake of Bahr el Tubat. The substrate in this habitat was hard, impervious, sandy clay which was furrowed with cracks and crevices and covered with encrustations of whitish salts.

***Gerbillus campestris patrizii* (de Beaux)**

*Dipodillus dodsoni patrizii* de Beaux, Ann. Mus. Civ. Stor. Nat. Genova, vol. 55, pp. 379–381, 1932 (El Giof, Cufra Oasis, Cyrenaica Province, Libya).

Specimens examined. Thirty-two, from Cyrenaica: El Hauuari, Cufra Oasis, 15; El Giof, Cufra Oasis, 17.

Measurements. Averages and extremes of 10 adult males and 7 adult females from the type locality are, respectively: Total length 211.8 (183–233), 213 (192–225); length of tail 118.4 (97–131), 121.7 (110–127); length of hind foot 26 (23–28), 26.1 (24–27); length of ear 15.9 (15–18), 15.7 (14–17); occipitonasal length of skull 29 (27.6–30.3), 28.6 (26.1–28.8); length of auditory bulla 9.3 (8.5–10), 9.3 (8.4–9.5); crown length of upper molariform toothrow 3.8 (3.4–4), 3.8 (3.3–4); greatest breadth across zygomatic arches 15.2 (14.3–15.8), 15.2 (14–16.2); least interorbital breadth 5.2 (4.8–5.4), 5.2 (5–5.6); breadth of rostrum at level of antorbital foramina 3.1 (2.8–3.3), 3.1 (2.8–3.3); length of nasals 11.2 (10.5–11.7), 10.9 (9.7–11.4).

Diagnosis. Representatives of this subspecies are extremely variable in dorsal coloration ranging from Ochraceous-Tawny through Avellaneous, Cinnamon, and Tawny-Olive. Nearly all specimens have strong suffusions of dark colors on the middorsal region and rump, which impart a streaked appearance to the entire dorsum. This variegated dorsal color is perhaps the most diagnostic and unifying character of this subspecies. Other characteristics of this subspecies are as follows: Postauricular patches indistinct and suffused with buff;

eye ring black; mystacial, rostral, and scapular areas Light Buff; vibrissae relatively long with a preponderance of black hairs; ears relatively long and pinnae sparsely haired, Antimony Yellow basally and Saccardo's Umber distally, with small tuft of buffy hairs on anterior margin; dorsal surfaces of forelegs, hindlegs, and feet white; ventral surfaces of hindlegs with strong suffusions of plumbeous-colored hairs; palmar and plantar surfaces of feet entirely naked, the latter with six distinct metatarsal tubercles; fore and hind feet each with five digits bearing claws; tail relatively short, distinctly bicolored in most specimens, ranging from tan to dark brown dorsally and from a medium buff to almost white ventrally (in some darkly colored specimens, the tail is almost uniformly colored throughout); tail markedly penicillate colored. Avellaneous to dark brown on distal one-third; basal portions of all dark colored hairs Deep Plumbeous; underparts white with occasional suffusion of buff. Skull: Noticeably small and compact for the species; auditory bullae small, but moderately inflated ventrally; zygomata heavy and narrow in breadth; interorbital breadth narrow; braincase, notably the parietals, flattened.

Comparisons. Members of this subspecies can be readily distinguished from those representing *Gerbillus campestris haymani* and *Gerbillus campestris wassifi* from farther north in Cyrenaica and western Egypt by the markedly smaller size of body and cranium, darker, more variable dorsal color, and more prominently tufted tail.

In general characters, these gerbils from Cufra Oasis most clearly resemble those of *Gerbillus campestris dodsoni*, whose range is to the west and north but differ in their smaller body size, shorter tail, and smaller size of all cranial measurements.

For comparison with *Gerbillus campestris brunnescens*, see account of that subspecies.

Remarks. De Beaux (1932, p. 379) described *Dipodillus dodsoni patrizii* (=*Gerbillus campestris patrizii*) as a new subspecies separable from *Dipodillus dodsoni dodsoni* (=*Gerbillus campestris dodsoni*) primarily by its smaller size. Setzer (1957) placed *G. c. patrizii* in synonymy under *G. c. dodsoni* and stated that the characters used by de Beaux in separating *patrizii* from *dodsoni* were all typical of subadult specimens of the latter. Setzer examined no specimens of typical *G. c. patrizii*, however, and apparently based this assignment solely on comparisons with the characters given in the original description. In cranial and external measurements, the large series of adult topotypes collected by the present author agree closely with those given by de Beaux in the original description. In studying these gerbils from Cufra, extreme care was taken to select only fully adult specimens. The present study indicates that gerbils from Cufra, primarily

because of their diminutive size, warrant reinstatement as a distinct subspecies.

Within series of these gerbils, all gradations of body size are noted, ranging in length from 230 mm to well below 200 mm. This wide range may reflect degenerative changes in the genotype of the population engendered by the agency of "drift" resulting from a long period of absolute physical isolation without any outbreeding with marginal populations. Specimens from nearby Bzema and Tazerbo Oases, although similar in color to those from Cufra, are clearly referable in their larger size and cranial characters to *G. c. dodsoni* and show no evidences of gene exchange with *G. c. patrizii*.

An adult male, 325348, from El Hauuari, is uniformly gray and lacks the typical variegated character of the dorsal pelage. This specimen probably represents an aberration in color without any genetic significance.

Ecological observations. The series from both El Hauuari and El Giof were collected among sedges and other mesophytic plants that occur as a fringe of dark green vegetation surrounding the low-lying saline lakes in the interior of these oases. In most areas, these sedges form almost impenetrable masses; consequently, trapping is usually limited to the periphery of the habitat. In these areas the substrate is extremely hard and impregnated with salts from adjoining lakes. These gerbils were never taken from the sandy areas of the oases proper. In these areas, *Gerbillus gerbillus* and *Acomys cahirinus* are the dominant rodents.

### *Gerbillus campestris wassifi* Setzer

*Gerbillus campestris wassifi* Setzer, Journ. Egypt. Publ. Health Assoc., vol. 33 no. 6, pp. 209–211, 1958 (Libyan Plateau, near Salum, ±200 ft., Western Desert Governorate, Egypt).

Specimens examined. Five (1 skin only), from 5 km W Bardia, Cyrenaica Province, Libya.

Measurements. Measurements of an adult male, 325509, from the above locality are: Total length 245; length of tail 135; length of hind foot 30; length of ear 17; occipitonasal length of skull 30.4; length of auditory bulla 9.3; crown length of upper molariform toothrow 4.1; greatest breadth across zygomatic arches 16; least interorbital breadth 5.5; breadth of rostrum at level of antorbital foramina 3.2; length of nasals 12.

Diagnosis. Dorsum Ochraceous-Tawny becoming lighter on sides and rostral areas, all parts with strong suffusions of darker hairs; pre- and postauricular spots and supraorbital patches conspicuous and white with faint admixture of buffy hairs; pectoral areas with indistinct buffy patch; eye ring black; circumoral areas, dorsal surfaces of forelegs, hindlegs, feet, and entire underparts white; ventral surface

of hindlegs and thighs with conspicuous plumbeous-colored patches, fore and hind feet naked ventrally, each with five digits with claws; vibrissae relatively long and formed of equal numbers of light and dark hairs; ears long, sparsely haired, Ochraceous-Buff basally and Brownish Olive distally and with distinct tuft of buffy hairs on anteroventral margin; tail prominently bicolored, dorsally same color as dorsum, but with stronger suffusions of brown hairs, ventrally almost white; tail with indistinct pencil; immature specimens of this subspecies markedly paler and more uniform in dorsal color, approaching Cinnamon-Buff, and lacking the strong suffusions of dark hairs. Skull: Large and robust; molariform teeth large; auditory bullae moderately inflated; anterior palatine foramina wide; zygomatic breadth wide; nasals long and posterior palatine canals wide and conspicuous.

Comparisons. From topotypes of *Gerbillus campestris haymani* from Siwa Oasis, Western Desert Governorate, Egypt, this specimen from Bardia differs in darker dorsal color with stronger suffusion of brown, markedly shorter and more prominently bicolored tail with a much reduced terminal brush, smaller auditory bullae, and smaller size of all other cranial details, being of comparable size only in the crown length of the molariform toothrow.

Compared to topotypes of *Gerbillus campestris dodsoni* from Ain Hammam, Tripolitania Province, Libya, this specimen from Bardia is paler and more uniform in dorsal color, has markedly smaller auditory bullae, wider interorbital breadth and rostrum, and less conspicuously tufted tail.

For comparisons with *Gerbillus campestris brunnescens* and *Gerbillus campestris patrizii*, see accounts of those subspecies.

Remarks. This specimen from Bardia differs from typical *G. c. wassifi* from Salum, Egypt, in having larger hind feet, a less prominently tufted tail, more grayish hairs on the head, slightly smaller auditory bullae, and slightly narrower anterior palatine foramina. In view of the geographic proximity of Bardia to the type locality of *wassifi* in Egypt and the continuity of habitat between them, even these subtle differences would not be expected. Thus, this single specimen may not possess characters typical of the whole population. These differences do not depart markedly from those considered typical for *G. c. wassifi*, and specimens from Libya are included with this subspecies.

In reviewing the dipodils of Egypt, Wassif (1956) assigned specimens from coastal Egypt to *Gerbillus campestris campestris;* the type locality of which is far to the west at Philippeville in the Province of Constantine on the Algerian Coast. He had no specimens of typical *G. c. dodsoni* but referred gerbils from Siwa Oasis, Egypt, to this subspecies.

He stated further that these coastal gerbils differed from those of the interior in their smaller size, denser fur, less tufted tails, and less variable dorsal pelage. Later, Setzer (1958) also recognized these differences and named *Gerbillus campestris wassifi*, with a range ascribed to northwestern coastal Egypt, and described *Gerbillus campestris haymani* representing the interior populations of Siwa Oasis. He concluded that by virtue of its smaller size and prominently biocolored tail, *G. c. wassifi* was more closely related to *G. c. dodsoni* than to *G. c. haymani* and attributed these similarities to the continuity of suitable habitat between the ranges of *G. c. dodsoni* and *G. c. wassifi*. At that time, however, the range of *G. c. dodsoni* was thought to include northern Cyrenaica and thus to be contiguous with that of *G. c. wassifi*. Northern Cyrenaica is now included within the range of a new subspecies, *G. c. brunnescens*, and it probably was to representatives of this subspecies, then known as *G. c. dodsoni*, that Setzer (1958) alluded in discussing the affinities of *G. c. wassifi*. It is now known that *G. c. wassifi* is more closely related to *G. c. brunnescens* than to either *G. c. dodsoni* or *G. c. haymani*. The range of *G. c. campestris* is thought to be confined to coastal Algeria and Tunisia and possibly northwestern Libya.

In Libya, the range of this subspecies is confined to the Mediterranean littoral of northeastern Cyrenaica at least as far west as Derna, where intergradation with *G. c. brunnescens* occurs.

The specimens from Bardia were collected among some localized concentrations of thorny, bushy perennials growing from residual mounds or elevations in the bottom of a recently flooded and denuded wadi.

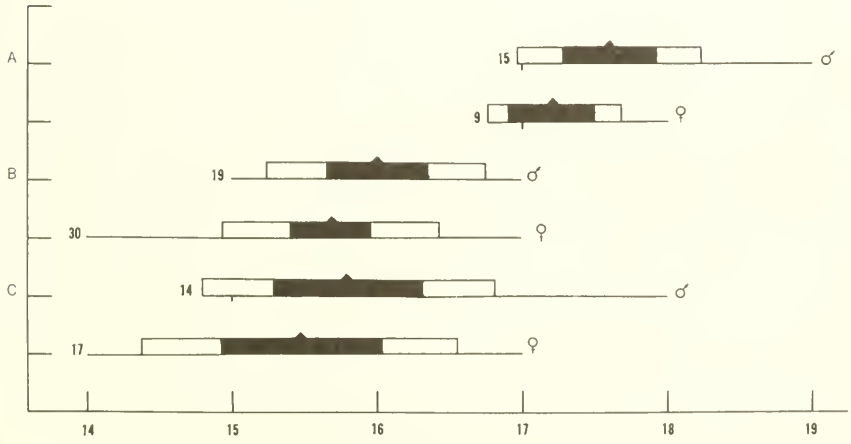


FIGURE 27.—Statistical comparison of length of ear of the subspecies of *Gerbillus campestris:* A, *G. c. brunnescens;* B, *G. c. dodsoni;* C, *G. c. patrizii.*

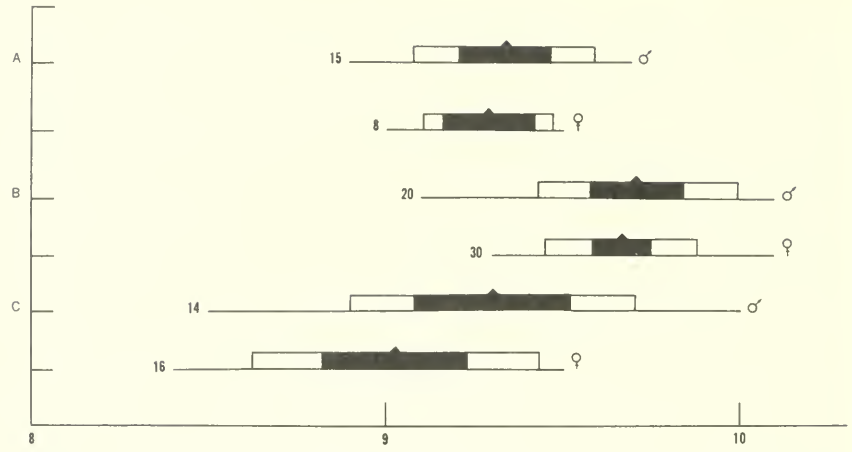


FIGURE 28.—Statistical comparison of length of auditory bulla of the subspecies of *Gerbillus campestris*. Notation remains the same as in figure 27.

### *Gerbillus grobbeni* Klaptocz

*Gerbillus* (*Dipodillus*) *grobbeni* Klaptocz, Zool. Jahrb. Syst., vol. 27, p. 252, 1909 (Derna, Cyrenaica, Libya).

REMARKS. No specimens of this gerbil were obtained in the present study. Judging from measurements given in the original description, this species most likely represents *Gerbillus amoenus*. Zavattari (1934) reported *G. grobbeni* from Libya, but mentioned no specimens other than those from the type locality. Later, Ellerman and Morrison-Scott (1951) suggested that *G. grobbeni* probably represented *Gerbillus nanus* Blanford. Toschi (1954) referred specimens from Derna and the Wadi el Kuf to *G. grobbeni* but considered the latter as a subspecies of *Gerbillus dasyurus* (Wagner). Setzer (1957) tried unsuccessfully to obtain topotypes of this species but made no comments regarding its probable status.

In the present work, gerbils representing the subgenus *Dipodillus* were obtained from both the type locality at Derna and from the Wadi el Kuf. These gerbils clearly represent *Gerbillus campestris* and *Gerbillus kaiseri*, neither of which approach very closely the measurements and description of *G. grobbeni* as given by Klaptocz in the original description.

This species is considered to be of doubtful validity but is being retained until such time as specimens are available to establish its true status.

### *Gerbillus henleyi henleyi* (de Winton)

*Dipodillus henleyi* de Winton, Nov. Zool., vol. 10, p. 284, August 1903 (Zaghig, Wadi Natroun, Egypt).

General distribution of species. Egypt, Sinai, Libya, and Algeria; range probably also includes Tunisia.

Distribution in Libya. Coastal plain and littoral deserts of northern Cyrenaica and the Gulf of Sirte.

Specimens examined. Six, from Cyrenaica: 11 km E Ain el Gazala, 2; 20 km E Tobruch, 3 (1 skin only); 65 km WNW El Agheila, 1.

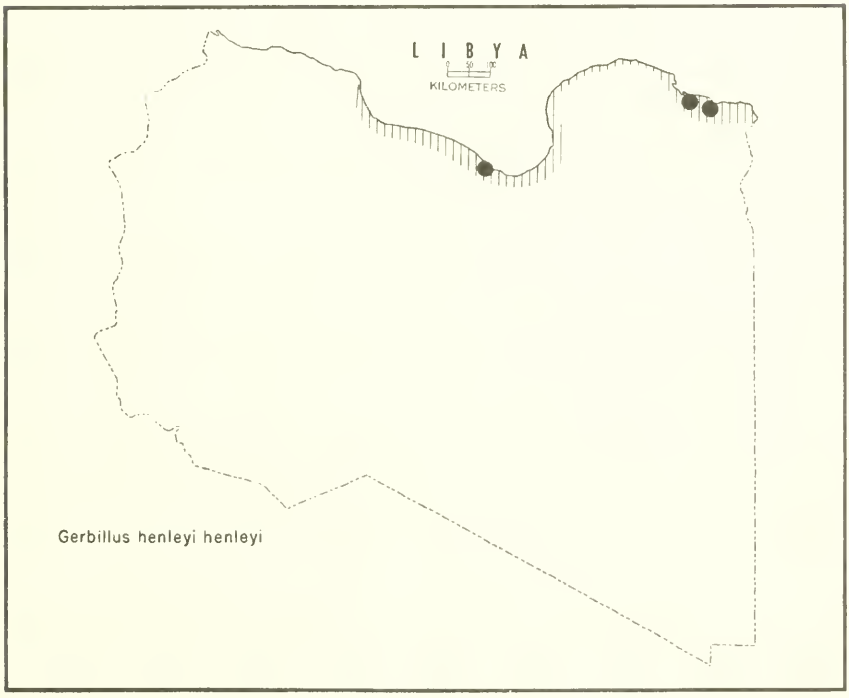


Figure 29.—Distribution of *Gerbillus henleyi henleyi*.

Measurements. Measurements of two adult males, 325540 and 325549, from 20 kilometers east of Tobruch, are: Total length 161, 162; length of tail 90, 94; length of hind foot 18, 19; length of ear 10, 10; occipitonasal length of skull 22, 21.9; length of auditory bulla 8.7, 8.7; crown length of upper molariform toothrow 2.8, 2.7; greatest breadth across zygomatic arches 12, 12; least interorbital breadth 4.3, 4.2; breadth of rostrum at level of antorbital foramina 2.4, 2.3; length of nasals 7.6, 7.6.

Diagnosis. Diminutive in size; pelage short and silky; upperparts Buckthorn Brown, uniformly suffused with darker hairs and becoming paler on sides and flanks; postauricular and supraorbital patches distinct and white; subauricular areas with strong admixture of black hairs; circumoral areas, portions of the cheeks, dorsal surfaces of forelegs, hindlegs, feet, and entire underparts pure white; vibrissae delicate and formed from both light and dark colored individual hairs; fore and hind feet extremely small, naked ventrally and each bearing five digits with claws; tail Pinkish Buff, relatively long and with faint terminal tuft, and appearing bicolored owing to moderate suffusions of dark brown hairs dorsally; pinnae of ears extremely short and sparsely haired; outer surfaces of pinnae approaching color of dorsum; internal surfaces somewhat bicolored, becoming darker distally and approaching Light Drab. Skull: Small and gracile; rostrum relatively short; zygomata fragile; molariform teeth small and diverging slightly anteriorly; braincase markedly expanded and appearing almost bulbous; auditory bullae noticeably large and markedly inflated ventrally; basioccipital triangular-shaped posteriorly and projecting anteriorly between auditory bullae as a narrow rod; posterior lacerated foramina large and distinct.

Comparisons. Compared to a topotype of *Gerbillus henleyi makrami* Setzer from Bir Kansisrob, Sudan Government Administrative Area, Egypt, these specimens from Libya are larger in all respects and have more prominently domed braincases.

From topotypical *Gerbillus henleyi mariae* (Bonhote) from the vicinity of Cairo, Egypt, these gerbils from Libya differ in having slightly shorter skulls, smaller and less inflated auditory bullae, wider interorbital breadths and rostra, shorter nasals, wider basioccipitals anteriorly, and smaller size of all external measurements except length of ears. In color, *G. h. mariae* is noticeably darker with a greater suffusion of grayish tones.

These specimens from Libya are almost indistinguishable from topotypes of *G. h. henleyi* from coastal Egypt but differ in slightly larger size of body, interorbital breadth and width of rostrum, and smaller occipitonasal length of skull. In overall size of body and occipitonasal length they are nearer to *G. h. mariae*, but because they share more characters with the nominate subspecies and have a range contiguous with populations of the latter in western Egypt, they are here referred to *G. h. henleyi*.

Remarks. The diminutive size of members of this species serves to distinguish them from all other gerbils in Libya. Until as recently as 1955, this distinctive species was unknown from Libya. Earlier collectors in Libya tended to concentrate their efforts in the interior oases and consequently neglected the coastal areas to which these

gerbils are largely confined. Even today the species is poorly known and is represented by comparatively few specimens from widely scattered localities.

Wassif (1956) assigned specimens from western coastal Egypt to *Gerbillus henleyi jordani* (Thomas), whose range is far to the west in the Central Plateau of Algeria. He had no specimens of *G. h. jordani* and based this assignment on similarities in size, particularly in the length of the auditory bullae. Later, Setzer (1958) referred all Egyptian specimens from west of the Nile River to *G. h. henleyi* and asserted that *G. h. jordani* did not occur in Egypt. The inclusion of the Libyan specimens within *G. h. henleyi* extends the range of the nominate subspecies even farther westward and indicates that *G. h. jordani* is not a part of the Libyan fauna.

In the original description of *Dipodillus jordani* (=*Gerbillus henleyi jordani*), Thomas (1918) distinguished it from *Dipodillus henleyi* (=*Gerbillus henleyi henleyi*) on the basis of the larger size of the former. This larger size of *G. h. jordani* was further indicated by Setzer, who compared members of the two subspecies at the British Museum. Measurements made by the author on specimens from Libya and of topotypical specimens of *G. h. henleyi* from coastal Egypt are larger, rather than smaller as would be expected, than those of the type specimen of *G. h. jordani*. For the present, until much larger series of these gerbils become available from Algeria and western Libya to provide more reliable comparative material, I prefer to regard *G. h. jordani* as a subspecies of uncertain status confined to the Central Plateau of Algeria.

Ecological observations. These small gerbils are apparently confined to the coastal plain and littoral deserts of northern Libya. Two specimens were obtained from near Ain el Gazala along the coastal highway where a series of large, exposed hummocks supported sparse growths of thorny perennials. These hummocks were riddled with larger burrows, presumably those of jirds (*Meriones*), as two of the latter were taken in the same trapline. Near Tobruch, three specimens were obtained from the broad coastal plain. At this locality, the plant cover was almost complete and continued uninterruptedly for several kilometers. According to Setzer (1957), the habitat near El Agheila is characterized by a "pebbly desert which is slightly raised above the coastal plain."

### *Gerbillus kaiseri* Setzer

*Gerbillus kaiseri* Setzer, Journ. Egypt. Public Health Assoc., vol. 33, no. 6, pp. 214–216, 1958 (Mersa Matruh, Western Desert Governorate, Egypt).

General distribution of species. Coastal areas of Libya and Egypt as far east as the Nile River; range probably also includes portions of Tunisia and Algeria.

Distribution in Libya. Coastal plain and littoral deserts of Cyrenaica and the uplands of the Gebel Nefusa and Gebel Tigrinna in Tripolitania.

Specimens examined. Twenty, from Cyrenaica: 3 km E Derna, 2; 2 km N Coefia, 6; 8 km N Benghazi, 2; 20 km E Tobruch, 5; from Tripolitania: 20 km E Rumia, 1; 12 km S Chicla, 4.

Measurements. Measurements of one adult male, 325028, and two adult females, 325027 and 325550, from 20 kilometers east of Tobruch, Cyrenaica Province, are, respectively: Total length 164, 169, 159; length of tail 83, 81, 77; length of hind foot 21, 21, 20; length of ear 12, 12, 12; occipitonasal length of skull 25.8, 26.3, 24.4; length of auditory bulla 8.4, 8.6, 8.1; crown length of upper molariform toothrow 3.5, 3.8, 3.5; greatest breadth across zygomatic arches 14.2, 14.2, 13.5; least interorbital breadth 5.1, 4.7, 4.6; breadth of rostrum at level of antorbital foramina 2.7, 2.6, 2.6; length of nasals 9.6, 9.7, 9.4.

Diagnosis. Color of the dorsum varying widely according to geographic locality and ranging from Light Ochraceous-Buff, Cinnamon-Buff, or Tawny Olive to Sayal Brown; complete dorsum

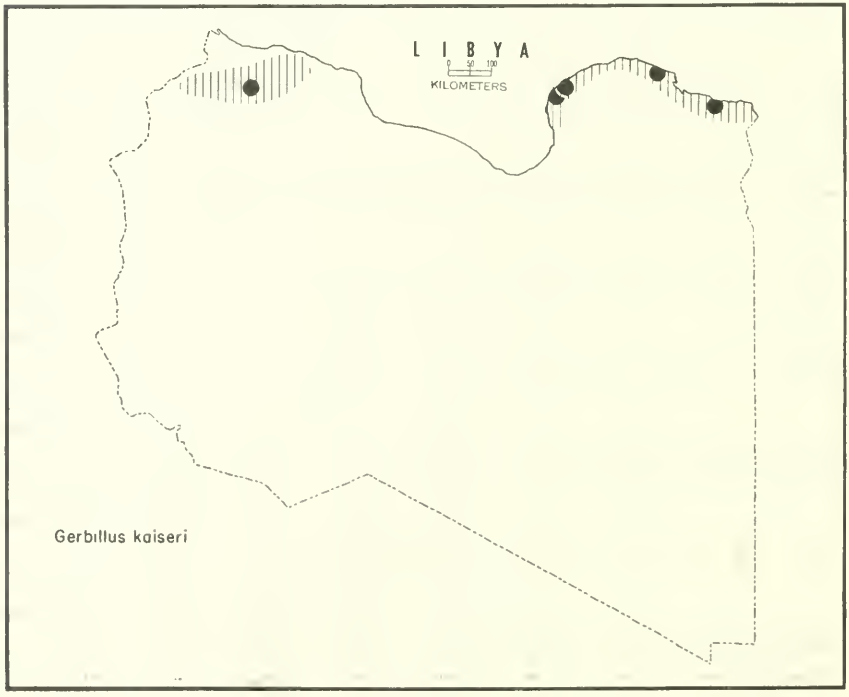


Figure 30.—Distribution of *Gerbillus kaiseri*.

interspersed with numerous brown-tipped hairs which render a variegated or particolored aspect to the pelage; in most specimens Plumbeous underfur exposed dorsally; region surrounding eyes heavily suffused with black and gray, in some specimens extending into subauricular area as a distinct patch; postauricular patches white and somewhat limited in size; rostral area Cinnamon-Buff; vibrissae relatively short, hairs having origin near the eye black whereas those arising nearer the tip of the rostrum white; pinnae of ears short, sparsely haired, Ochraceous-Buff basally and Hair Brown distally and with prominent tufts of silky, buffy hairs arising from the anterior margins; circumoral areas, pectoral region, dorsal surfaces of forelegs, hindlegs, feet, and entire underparts white; fore and hind feet naked ventrally and each bearing five digits with claws; tail noticeably short, unicolorous, except for suffusions of brown hairs dorsally, and somewhat paler in color than that of the dorsum; a pencil or terminal tuft is lacking. Skull: Small; anterior palatine foramina long and wide; posterior palatine canals distinct and relatively wide; auditory bullae small and slightly inflated ventrally; basioccipital present as a rather broad triangular plate between the auditory bullae and forming an elongated foramen on its lateral margins; zygomata relatively fragile; braincase moderately domed; in very old adults a distinct longitudinal fossa present on the medial surface of the frontals extending forward to the level of the infraorbital foramina.

Comparisons. Specimens from Libya somewhat resemble a specimen (MNHN, no. 1789) of *Gerbillus simoni* Lataste from Guelt es Stel, Algeria, but differ in noticeably longer tails, less robust skulls, much more fragile zygomata, and paler, shorter, less lustrous fur. Unfortunately, the auditory bullae, which are reputedly of taxonomic significance in distinguishing *G. simoni* from *G. kaiseri*, are badly broken in this specimen of *G. simoni* from Algeria, and comparisons based on this character are not possible.

Members of this species can be readily distinguished from all other dipodils in Libya by their markedly shorter and almost unicolorous tails and the absence of a well-defined terminal tuft.

Remarks. Wassif (1956) assigned specimens from coastal Egypt to *Gerbillus simoni*. This assignment was based on resemblances to the measurements and descriptions of *G. simoni* as given by Lataste (1881). Prior to this time, no specimens of *G. simoni* were known from outside Algeria. Earlier, Ellerman (1941) included *G. simoni* and *G. henleyi* within the *G. simoni* group but stated that *G. simoni* could readily be distinguished from *G. henleyi* and all other members of the group by its smaller auditory bullae. Later Ellerman (1949) and Ellerman and Morrison-Scott (1951) considered *G. simoni* as a sub-

species of *Gerbillus dasyurus* (Wagner). The latter assignment has no morphological or taxonomic justification, as the two forms have nothing in common to suggest conspecificity. Setzer (1958), although recognizing that these gerbils from Egypt and those from Algeria were related, considered the Egyptian specimens to represent a new species, *G. kaiseri*, distinguished from *G. simoni* primarily by its significantly longer tail. He did not compare the crania of the two species but inferred that those of *G. kaiseri* would be larger and suspected those of *G. simoni* to be about the same size as those of *G. henleyi*. Judging from the single specimen of *G. simoni* from Guelt es Stel, Algeria, the two species are somewhat comparable in cranial size, but *G. simoni* appears to be more robust, particularly in having heavier and more massive zygomatic arches. Compared to *G. henleyi*, both *G. kaiseri* and *G. simoni* are markedly larger cranially, have much shorter and more unicolorous tails, proportionately smaller auditory bullae, larger ears, and larger size of body.

The present series from Cyrenaica and Tripolitania constitutes the first record of occurrence of *G. kaiseri* in Libya. Gerbils from the Cyrenaican coast differ from topotypes and near topotypes of *G. kaiseri* from Egypt in their slightly darker dorsal color and shorter tails, but in all other characters the two populations are almost indistinguishable. Specimens from the Gebel Nefusa in Tripolitania, although geographically closer to the type locality of *G. simoni* in Algeria, possess all characters typical of *G. kaiseri* and show no evidences of interbreeding with *G. simoni*. It is now clear that *G. kaiseri* and *G. simoni* represent two distinct species with separate ranges ascribed to each. The range of the former includes the littoral areas and coastal escarpments of Libya and Egypt, and *G. simoni* is confined to the high plateaus of the Algerian Atlas.

Within Libya the various discontinuous populations are remarkably uniform in color and cranial characters. Specimens from Derna, however, are slightly darker than those from elsewhere in Cyrenaica, and four specimens from Tripolitania have smoother, more sparsely haired tails than any of the other populations of this gerbil in Libya. Adequate series are still lacking and a more thorough analysis of the differentiation among the various populations will have to be deferred until a later date. It is doubtful that populations distributed over such a wide geographic area represent the same subspecies.

Ecological observations. In Cyrenaica these gerbils are confined to the relatively narrow coastal plain and adjacent lowlands. Apparently they prefer habitats lacking sand. Traplines set throughout coastal dunes failed to take any of these gerbils. Farther west in Tripolitania four specimens were collected from the highest portions of the Gebel Nefusa in the upper reaches of narrow, grassy valleys

that eventually drain through the escarpment into the coastal plain. In these high, windy valleys vegetation is rather abundant and consists largely of grasses and other herbs.

These gerbils were never collected in large series and were usually taken less frequently in traps than other species. Other species of rodents occurring sympatrically with this species include *Gerbillus campestris, Gerbillus eatoni, Gerbillus henleyi, Gerbillus aureus, Gerbillus amoenus,* and *Jaculus orientalis.*

The sporadic distribution of these gerbils in coastal Libya is unaccountable, as suitable habitats are present throughout virtually all of coastal Libya.

This species is unknown from the coastal areas of Tripolitania and the coastal plain of the Gulf of Sirte; however, more extensive collecting in these areas will probably reveal its presence.

## Genus *Pachyuromys* Lataste

### *Pachyuromys duprasi natronensis* de Winton

*Pachyuromys dupresi* (sic) *natronensis* de Winton, Nov. Zool. vol. 10, p. 285, 1903 (Bir Victoria, on way to Wadi Natroun from the Nile, Egypt).

General distribution of species. North Africa, including Egypt, Libya, Tunisia and Algeria, and southward into Mauritania.

Distribution in Libya. Hamadas of Tripolitania, Cyrenaica, and the northern Fezzan, and interior portions of the coastal plain of the Gulf of Sirte in Cyrenaica and Tripolitania.

Specimens examined. Twenty-four, from Cyrenaica: 65 km WNW El Agheila, 1; Wadi er Rueis, 340 km WNW Tazerbo Oasis, 1; from Tripolitania: 20 km E Rumia, 9; 3 km W Rumia, 2; 12 km S Chicla, 5; 7 km S El Gheddahia, 1; 5 km E Sirte, 2; 55 km SW Bir Allagh, 1; 15 km WNW Marble Arch, 1; 5 km E Derg, 1.

Published records in Libya. Cyrenaica: El Agheila (de Beaux, 1932); Zauia Mechili (de Beaux, 1938); Fezzan: Bir el Fatia (Toschi, 1951).

Measurements. Averages and extremes of six adult males and the measurements of two adult females from 20 kilometers east of Rumia, Tripolitania, are, respectively: Total length 165.5 (158–175), 155, 153; length of tail 55 (51–58), 51, 52; length of hind foot 23.5 (23–24), 22, 22; length of ear 17.2 (17–18), 15, 15; condylobasal length of skull 31.5 (30.8–32.1), 29.8, 29.7; greatest length of skull 37.7 (36.6–39.2), 35.8, 34.8; greatest breadth across auditory bullae 21.7 (21.2–22.3), 20.5, ?; crown length of upper molariform toothrow 4.9 (4.6–5), 4.7, 4.7; least interorbital breadth 6.1 (5.9–6.3), 6, 6.1; greatest length of nasals 12.9 (12.3–14), 11.9, 11.7; length of auditory bulla 18 (17.4–18.7), 16.9, 16.9; depth of auditory bulla 14.2 (13.8–14.5), 13.5, 12.8; greatest breadth across zygomatic arches 19.3 (18.7–19.9), 17.9, 18.5.

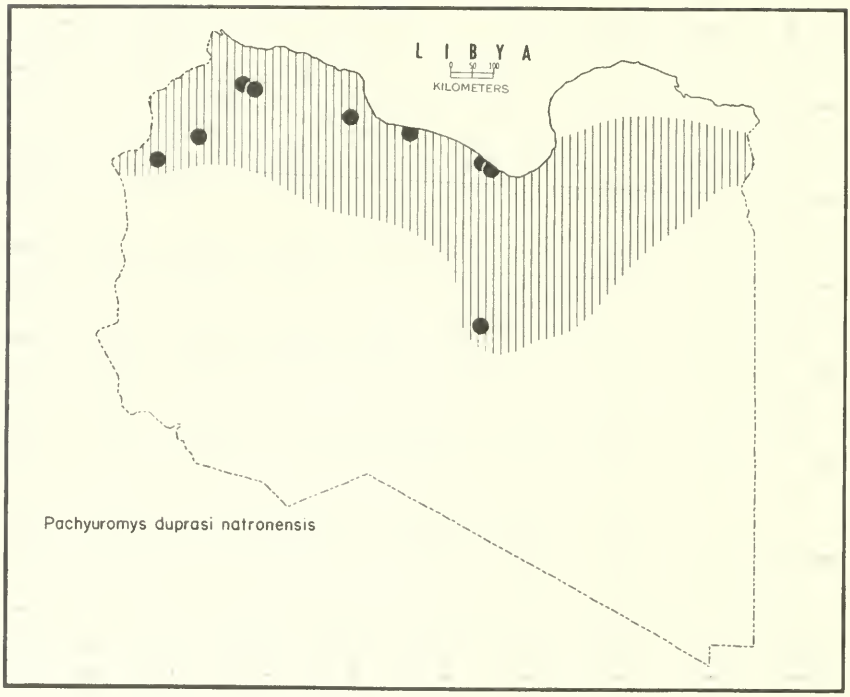


FIGURE 31.—Distribution of *Pachyuromys duprasi natronensis*.

DIAGNOSIS. Body noticeably compact and almost wedge-shaped in outline; pelage of dorsum long, silky and lustrous, ranging in color from Cinnamon-Buff to light Pinkish Cinnamon, a few more brilliantly colored specimens approaching orangish-buff; all parts of dorsum with medium to strong suffusions of brown and black hairs, being particularly concentrated on the rump; pelage of sides and scapular areas paler in color than the dorsum and less uniformly suffused with darker hairs; postauricular patches indistinct or absent; ears sparsely haired, about same color as the dorsum, and with prominent tufts of Cinnamon-Buff hairs on anteroventral margins; eye rings dark brown; area between eye and base of the ear strongly suffused with dark brown hairs and in some specimens, present as a distinct dark band extending from the eye to the ear; vibrissae soft, silky, and composed of both light and dark hairs; palmar and plantar surfaces sparsely haired, the latter with bare area in region of calcaneus; fore and hind feet each with five digits bearing pale colored claws; circumoral areas, chin, dorsal surfaces of forelegs, hindlegs, feet, and entire underparts pure white; tail extremely short, markedly enlarged in girth owing to its function as a storage depot for fat, approaching

same color as the pelage of the dorsum, but with faint suffusions of whitish hairs on ventral surface. Skull: Medium in size; flattened dorsoventrally and wedge-shaped; parietal ridges poorly defined; suprameatal triangles large and usually completely enclosed by enveloping processes of the supraoccipital and temporal bones; auditory bullae conspicuously enlarged and inflated ventrally; audital portions of bullae extending posterior to mastoidal processes and covering almost one-half of ventral surface of skull; meatal processes markedly enlarged and projecting farther laterally than the squamous portions of the temporal bones to which they are firmly adpressed; mastoidal portions of bullae also markedly enlarged and bulbous, and projecting conspicuously beyond the level of the occiput; pterygoid processes relatively short; hamulae firmly applied to anterior surface of the auditory bullae; anterior palatine foramina and posterior palatine canals markedly enlarged and bowing laterally; zygomata relatively delicate and slightly convergent anteriorly; lachrymals relatively small.

Comparisons. This species resembles *Meriones libycus* but can easily be distinguished from it and from all other jirds by its markedly shorter and heavier tail, larger auditory bullae, and more wedge-shaped body.

From a near topotype of *Pachyuromys duprasi duprasi* Lataste from Ghardaia, Algeria, specimens from 20 kilometers east of Rumia, Tripolitania, and those from various localities around the Gulf of Sirte, differ in having more gracile and less robust skulls (particularly more delicate zygomata), markedly larger posterior palatine canals, and longer and narrower rostra. Most of the Libyan specimens are also darker in dorsal color and smaller in external and cranial dimensions, being of comparable or larger size in length of ears, crown length of upper molariform toothrows, length of nasals, and length of auditory bullae.

A single specimen (skin only, BM, no. 39.2168) of *Pachyuromys duprasi faroulti* Thomas from Mecheria, western Algeria, is markedly darker in dorsal color than the Libyan specimens and has silkier, more lustrous pelage. Cranial comparisons are not possible at this time, but presumably *P. d. faroulti* differs significantly from Libyan specimens, as the range of the latter is confined to the High Plateau of northern Algeria and is, geographically, far removed from the Libyan populations.

Remarks. Although the specimens from near Rumia, Tripolitania, are clearly referable to *Pachyuromys duprasi natronensis*, they differ from topotypes of the latter from Bir Victoria, Western Desert Governorate, Egypt, in being larger in condylobasal length of skull, and in having slightly larger auditory bullae, slightly wider zygomata,

and longer ears. These specimens from Rumia are also darker in dorsal color, including the tail, and have a more marbled appearance dorsally, owing to a much stronger suffusion of brownish hairs.

Compared to specimens from Rumia, specimen, 321831, from 5 kilometers east of Derg and another specimen, 321832, from 55 kilometers SW of Bir Allagh, Tripolitania, have a more streaked pelage, and the dorsal lip of the external auditory meatus is more inflated and more closely applied to the squamous portion of the temporal. In the above characters, these two specimens resemble *P. d. duprasi* of Algeria, but in all other characters, they are closer to *P. d. natronensis*. Toschi (1951) referred a specimen from Bir el Fatia, Fezzan Province, to *P. d. duprasi*. He apparently based this assignment largely on geographic grounds, as the measurements of this specimen are much closer to those of topotypes of *P. d. natronensis*.

Specimens from the coastal plain of the Gulf of Sirte in Tripolitania are the palest in dorsal color and have the smallest hind feet of all representatives of this species in Libya.

In view of the rather wide range of this species in Libya, specimens from the various localities are remarkably uniform morphologically. These similarities suggest a relatively constant genetic interchange among the various populations rendered possible by the continuity of suitable habitat throughout most of coastal Libya. With the exception of two specimens, 321831 and 321832, from western Tripolitania, a single specimen from Bir el Fatia in the Fezzan (Toschi, 1951), and a specimen, 325582, from the Gebel el Harug el Asued of central Cyrenaica, this species in Libya is almost exclusively restricted to localities near the coast. The comparatively few specimens available at the present time cannot serve as a reliable index to their distribution in Libya, and their range doubtless includes a much greater portion of the interior than presently is supposed.

A single adult male specimen, 325582, from the Wadi er Rueis, Gebel el Harug el Asued, central Cyrenaica, is the southernmost record for this species in Libya, and it differs strikingly from all other representatives of this species in Libya by much paler dorsal color and markedly smaller size of all measurements. Unfortunately, the pelage of this specimen is badly worn, and the skull is badly broken rendering certain cranial measurements unavailable. If this specimen is typical of those comprising the population in this region of Cyrenaica, it clearly represents a new subspecies. The jerboas (*Jaculus deserti vastus*) of this isolated region have also undergone significant changes in size and cranial dimensions. A moderate amount of morphological divergence is not uncommon among populations of geographic isolates.

Ecological observations. The range of fat-tailed sand rats, in Libya, closely corresponds to that of several other species of rodents,

particularly *Meriones libycus*, *Gerbillus eatoni*, and *Psammomys obesus*. These unusual rats are most abundant in the transitional deserts which run roughly parallel to the more lush coastal plain. They seem to prefer the flat, rock-strewn surfaces of the hamadas and the margins of the shallow, dry watercourses which dissect them. In these areas, the surface is covered with coarse pebbles and occasionally with larger boulders, and the vegetative cover is usually sparse and localized. The collecting localities near Rumia and Chicla in Tripolitania are located on the broad uplands near the brink of the coastal escarpment where vegetative cover is denser, and the ground is rockier with occasional outcroppings of larger rocks.

Setzer (1957, p. 60) reported the habitat near El Agheila as consisting of a "rock shingle type of desert," and suspected that local, terrestrial snails provided a source of food for fat-tailed sand rats.

### Genus *Meriones* Illiger

The first records of members of this genus in Libya are those of Thomas (1902, p. 8), who, reporting on specimens obtained by Edward Dodson of the Whitaker Expedition to Tripoli (1901), referred specimens from various localities in Tripolitania and the Fezzan to *Meriones shawi* (Rozet) and *Meriones schousboei* (Loche). Thomas noticed "characteristic differences" in the size of the auditory bullae but mentioned that the two species were almost indistinguishable in external characters and would probably prove to be "mutually exclusive." He considered *M. schousboei* as the Barbary representative of the *Meriones erythrourus* (Gray) group, the latter being widely distributed throughout the Middle East and Southwest Asia.

Later, Thomas (1919), in an effort to clarify the confusion of names applied to this group, divided the genus into four groups based on the relative size and shape of the auditory bullae and the suprameatal triangle. Members of group "a" with large auditory bullae and large suprameatal triangles included *Meriones pelerinus* Thomas, *Meriones crassus* Sundevall, and *Meriones pallidus* Bonhote. Group "b," consisting of animals with large auditory bullae but comparatively small suprameatal triangles, included *Meriones libycus* Lichtenstein and *M. schousboei*. Those possessing both small auditory bullae and triangles formed group "c," which consisted of *Meriones isis* Thomas and *M. shawi*. The last division, group "d," consisted of those types having the smallest auditory bullae and included *Meriones syrius* Thomas, *Meriones charon* Thomas, *Meriones ambrosius* Thomas, and *Meriones blackleri* Thomas, whose ranges were confined to Asia Minor and Southwest Asia. The majority of the above species were described as new at this time.

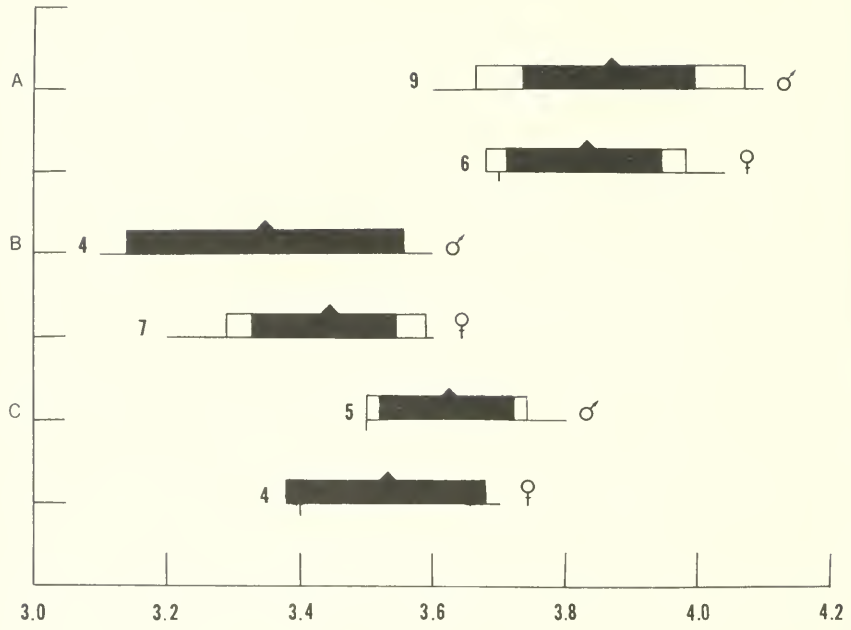


FIGURE 32.—Statistical comparison of breadth of rostrum of the species of *Meriones:* A, *M. caudatus;* B, *M. crassus;* C, *M. libycus.*

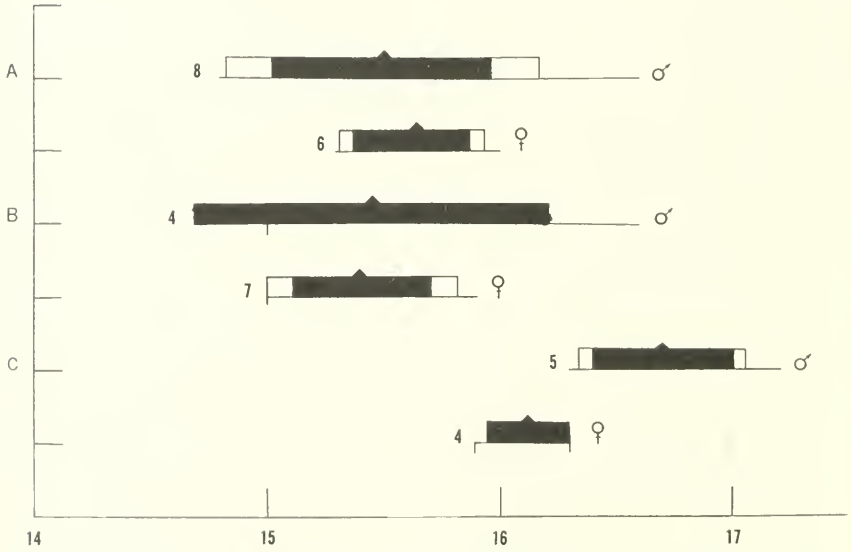


FIGURE 33.—Statistical comparison of length of palate of the species of *Meriones.* Notation remains the same as in figure 32.

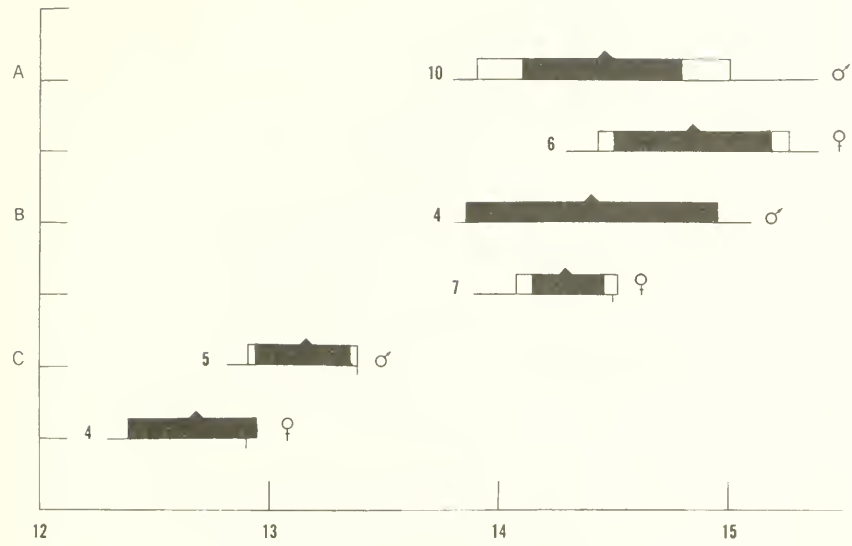


FIGURE 34.—Statistical comparison of length of audital portion of auditory bulla of the species of *Meriones*. Notation remains the same as in figure 32.

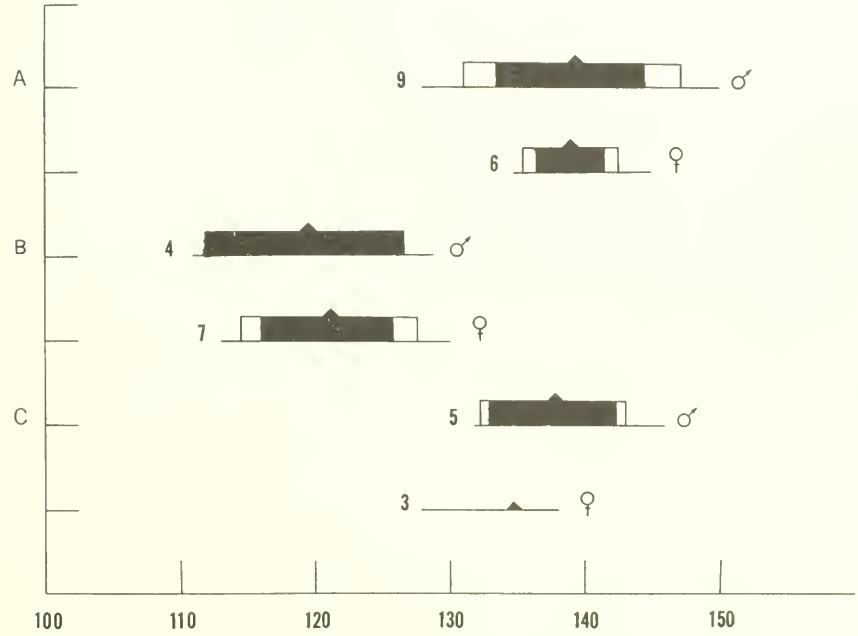


FIGURE 35.—Statistical comparison of length of head and body of the species of *Meriones*. Notation remains the same as in figure 32.

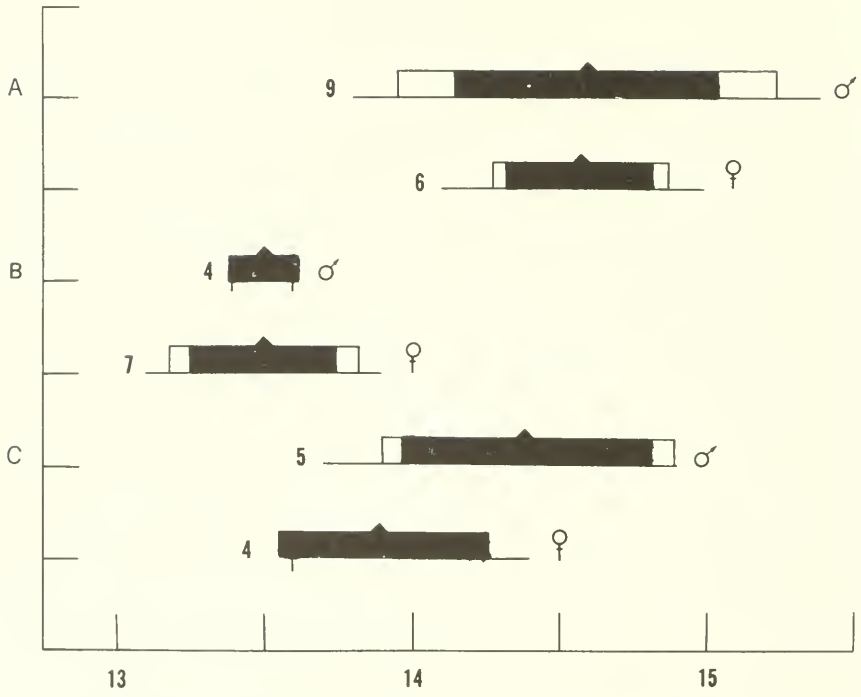


FIGURE 36.—Statistical comparison of length of nasals of the species of *Meriones*. Notation remains the same as in figure 32.

In Libya, local representatives of groups "a," *M. pallidus tripolius* Thomas; "b," *M. libycus caudatus* Thomas; and "c," *M. shawi* were recognized. *Meriones pallidus tripolius* from the Gebel Limhersuk, Tripolitania, and *M. libycus caudatus* from Bir Ferdjan (=Fergian) El Hammam (=Ain Hammam) were described as new subspecies in the same paper.

In Algeria, *Meriones richardi* (Loche) represented the "*shawi*" group north of the Atlas. Populations to the south of the Atlas were referred to *Meriones guyoni* (Loche) and *M. schousboei*, which Thomas considered as being "doubtfully separable" from *libycus*.

Ellerman (1941) divided the genus *Meriones* into three subgenera, *Parameriones* Heptner, *Cheliones* Thomas, and *Meriones*, based on the degree of hairiness of the sole of the hind feet. The latter subgenus contained all of the North African species, consisting primarily of *M. libycus*, *M. schousboei*, and *M. erythrourus*. These three species, in addition to *M. grandis* Cabrera, *M. trouessarti* Lataste, *M. kozlovi* Satunin, *M. longifrons* Lataste, *M. ismahelis* Cheesman and Hinton, *M. arimalius* Cheesman and Hinton, and *M. charon*, constituted the "*libycus*" group. Ellerman (1941) included all of the Libyan jirds

in the single species, *M. libycus*. He considered *M. shawi* as a synonym of *M. l. libycus* and relegated *M. crassus* to subspecific status. *Meriones erythrourus*, whose range included Russia and Southwest Asia, was given specific rank but thought possibly to represent only a subspecies of *M. libycus*.

In a later paper, Ellerman (1947) further divided the genus into two additional subgenera, *Sekeetamys* Ellerman and *Pallasiomys* Heptner, based upon both the hairiness of the hind feet and the relative size of the auditory bullae, and placed all the forms with large bullae, including all of the Libyan forms, in the subgenus *Pallasiomys*. In addition, *M. crassus* was elevated to specific rank and *M. shawi* withdrawn from synonymy and established as a subspecies of *M. libycus*. Thus the Libyan representatives of this genus were treated as two full species, *M. libycus* and *M. crassus*.

Later in the year Ellerman and Chaworth-Musters in "A Revision of the Genus *Meriones*" (1947), because of the sympatry of *M. l. shawi* and *M. l. caudatus*, separated *M. shawi* specifically from both *M. crassus* aud *M. libycus*. The above authors separated *M. libycus* from the other two species by certain external characters (hind claws dark=*libycus;* hind claws pale=*crassus* and *shawi*), and *M. crassus* and *M. shawi* were distinguished by the size of the auditory bullae (large in *crassus;* small in *shawi*). In addition to the coloration of the hind claws, the degree of closure of the suprameatal processes was given as a character separating *M. crassus* and *M. libycus*.

Toschi (1954) also recognized three species of the genus *Meriones* in the Libyan fauna, *M. libycus*, *M. crassus*, and *M. shawi*, represented by five subspecies, including the nominate subspecies of all three species and *M. libycus caudatus* and *M. l. confalonierii* de Beaux. Setzer (1957), the most recent worker on Libyan mammals, included the same three species in the Libyan fauna but considered *M. crassus tripolius* distinct from *M. c. crassus* and did not recognize *M. libycus libycus* and *M. c. crassus* as occurring in Libya. In addition, he described *M. shawi azizi* as a new subspecies from the northern Cyrenaican coast. Later, in reviewing the mammals of Egypt, Setzer (1961) did not consider *M. shawi* as part of the Egyptian fauna and, furthermore, questioned its validity as a species. He was unable to find any specific differences between *M. shawi* and *M. libycus* and concluded that the former was probably conspecific with *M. libycus* farther west in North Africa. The present author also doubts the validity of the species *M. shawi*.

Specimens from coastal Libya, formerly referred to *Meriones shawi shawi* and *Meriones shawi azizi* by Setzer (1957), are now considered to be referable to *Meriones libycus* and are now known, respectively, as *Meriones libycus auratus* (new subspecies) and *Meriones libycus azizi*.

However, certain bushy-tailed forms, previously recognized as *Meriones libycus confalonierii* de Beaux and *Meriones libycus caudatus* Thomas, are sympatric with these coastal subspecies of *M. libycus*. It therefore becomes necessary to separate these populations taxonomically. Because the name *caudatus* is older, it is here raised from subspecific status to full species rank. These populations may now be referred to as *Meriones caudatus caudatus* and *Meriones caudatus confalonierii*.

The jirds of Libya are here considered to be represented by the following three species and seven subspecies, three of which are here described as new: *Meriones caudatus amplus; Meriones caudatus caudatus; Meriones caudatus confalonierii; Meriones caudatus luridus; Meriones crassus tripolius; Meriones libycus auratus;* and *Meriones libycus azizi*.

The size and shape of the suprameatal triangle and the amount of closure of the latter by the enveloping processes of the supraoccipital and temporal bones varies among the three species of *Meriones* and serves to readily separate them. In *M. crassus*, the suprameatal triangles are markedly larger than those of *M. caudatus* and *M. libycus* and are open behind rather than completely or partially enclosed by the supraoccipital and temporal bones. The suprameatal triangles are of comparable size in *M. caudatus* and *M. libycus*, but in *M. caudatus* the closure of the suprameatal triangles is complete, whereas in *M. libycus* it is usually imperfect.

Individual genetic variation (nongeographic) is relatively high among populations of jirds in Libya, yet the peculiar physiography has resulted in the formation of several distinct subspecies. Morphological features most frequently associated with geographical distribution include differences in the length of the skull, palate, and nasals, and changes in the shape and size of the audital and mastoidal portions of the auditory bullae. In addition to cranial characters, the size and general form of external features are taxonomically important. Color, although sometimes highly variable within a given population, is frequently useful in differentiating the various subspecies.

The subspecies of the several species of *Meriones*, especially those of *M. caudatus*, are generally more sharply defined morphologically than those of the various species of *Gerbillus*. This apparent morphological segregation in *Meriones* may be misleading, inasmuch as the samples representing the subspecies are much smaller than those available for *Gerbillus* and may not demonstrate the complete range of variation for any given character.

Of the three species of *Meriones* occurring in Libya, only *Meriones caudatus* is represented by samples of sufficient size to justify statistical analysis at the infraspecific level.

### Key to the Jirds (Meriones) of Libya

1. Suprameatal triangle large and not enclosed posteriorly by enveloping processes of temporal and supraoccipital bones; mastoidal portion of auditory bulla conspicuously inflated posteriorly and projecting markedly beyond level of occiput . . . . . **M. crassus**

   Suprameatal triangle small and enclosed posteriorly by enveloping processes of temporal and supraoccipital bones; mastoidal portion of auditory bulla not conspicuously inflated posteriorly and projecting only slightly beyond level of occiput . . . . . 2

2. External meatal process of auditory bulla markedly inflated and adnate to squamous portion of temporal bone; suprameatal triangle completely enclosed by enveloping processes of the temporal and supraoccipital bones; tail relatively long and prominently tufted . . . . . **M. caudatus**

   External meatal process of auditory bulla not markedly inflated and clearly distinct from squamous portion of temporal bone; suprameatal triangle imperfectly enclosed by enveloping processes of the temporal and supraoccipital bones; tail relatively short and without prominent tuft. **M. libycus**

#### *Meriones caudatus* Thomas

*Meriones libycus caudatus* Thomas, Ann. Mag. Nat. Hist., ser. 9, vol. 3, p. 267, March 1919 (Tamari-Fergian, Tripolitania, Libya).

General distribution of species. Currently known only from Libya, but range probably includes other portions of North Africa and adjacent Southwest Asia.

Distribution in Libya. Widespread throughout the desert areas of Tripolitania and the Fezzan. In Cyrenaica, this species is known only from the coastal plain and the hamadas surrounding the oasis of Giarabub.

Distribution of the subspecies in Libya.

*Meriones caudatus amplus.* Fezzan: Oases of Murzuch, Traghen, Meseguin, El Gatrun, and intervening wadis and hamadas.

*Meriones caudatus caudatus.* Tripolitania: Coastal plain and interior deserts north of the Hamada de Tinrhert and Gebel es Soda.

*Meriones caudatus confalonierii.* Cyrenaica and Tripolitania: Coastal plain and littoral deserts adjoining the Gulf of Sirte.

*Meriones caudatus luridus.* Cyrenaica: Coastal areas of northern Cyrenaica and the inland hamadas as far south as Giarabub Oasis.

Published records in Libya. Cyrenaica: El Agheila (de Beaux [*Meriones libycus confalonierii*], 1932); El Agheila (*Meriones libycus confalonierii*), Giarabub (*Meriones libycus caudatus*) (Toschi, 1951). Tripolitania: Ain Hammam and Tamari-Faradie (Toschi [*Meriones schousboei*], 1951).

Comparisons. This species differs from *Meriones libycus* as follows: Tail longer, with more prominent pencil, and black rather than brown; auditory bullae noticeably larger and more inflated ventrally and laterally; lateral meatal process of auditory bulla markedly expanded

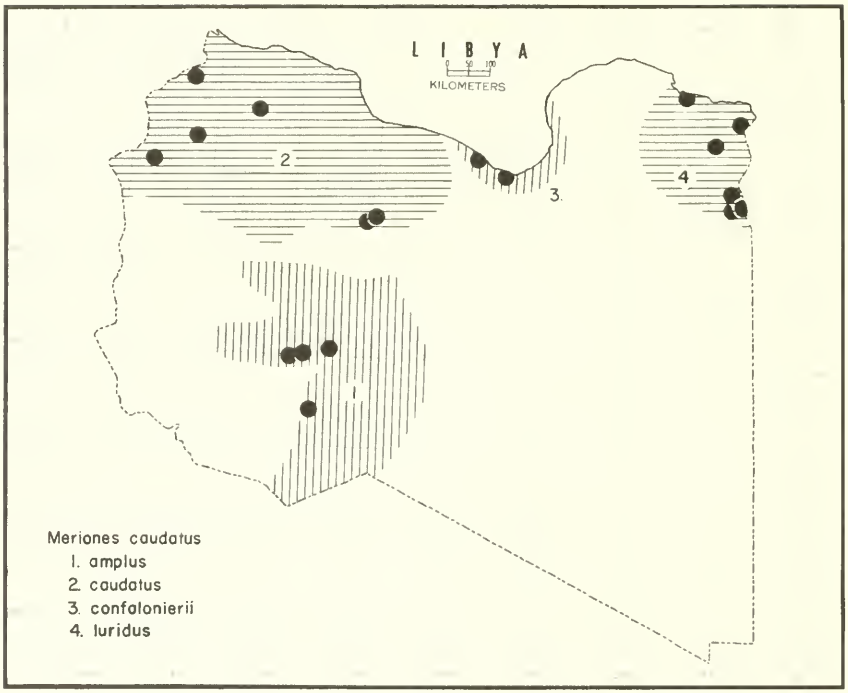


FIGURE 37.—Distribution of the subspecies of *Meriones caudatus*.

and applied to squamous part of temporal bone, as opposed to lateral meatal process only slightly expanded and clearly distinct from squamous part of temporal bone in *M. libycus;* suprameatal triangle elliptical in shape, rather than spherical, with posterior processes completely closed, as opposed to imperfectly closed in *M. libycus.*

*Meriones shawi* is regarded as a species of doubtful validity and probably is synonymous with *Meriones libycus.* Specimens representing *M. shawi* from Algeria differ from topotypical *M. caudatus* in the same characters as those used to separate *M. libycus* and *M. caudatus,* except that the Algerian specimens have even smaller auditory bullae.

For comparison of this species with *Meriones crassus,* see account of that species.

REMARKS. Thomas (1919) described *Meriones libycus caudatus* from Ferdjan (=Bir Fergian), Tripolitania Province, and assigned another specimen from nearby Ain Hammam to this subspecies. He separated *M. l. caudatus* from typical *M. l. libycus,* as known from the vicinity of Cairo, Egypt, primarily by its "markedly longer and finer tail," and stated that it occurred between the ranges of the original *Meriones libycus* of Lower Egypt and *Meriones schousboei* of Algeria. Later, *M.*

*schousboei* was treated as a subspecies of *Meriones libycus* by de Beaux (1932) and Chaworth-Musters and Ellerman (1947) and more recently regarded as a synonym of *Meriones libycus libycus* by Ellerman and Morrison-Scott (1951). In the present study, more specimens of *M. caudatus* are available from numerous localities throughout Libya, and the taxonomic position of this jird is better understood. In addition to the bushy character of the tail, as established by Thomas (1919), several cranial characters are apparent (see comparisons above) which clearly establish *M. caudatus* as a distinct species from *M. libycus* of the Western Desert of Egypt. Its specific status is confirmed by its being sympatric with populations of *M. libycus* from several localities in coastal Libya.

The use of the name *M. caudatus* for this species can only be considered provisional at this time. It appears to be the oldest name available for the Libyan population, but extralimital material (presently assigned to *M. libycus*) that I have examined from Algeria (Beni Ounif) and Iran (Khurasan, Baluchistan, and Kopet Dag Mountains) indicates that the present species is widespread in distribution and probably occurs over large portions of both North Africa and Southwest Asia. It seems almost certain that older names are available, but until additional material is forthcoming and a thorough revision of *Meriones* throughout its entire range can be undertaken, the name *M. caudatus* must serve for the Libyan population.

Ecological observations. This species is probably the most abundant and widely distributed large rodent in Libya. These jirds seem to prefer arid habitats and reach their greatest numbers in the deserts of the Saharan interior. They occur sporadically, however, in the coastal areas, where they are sympatric with *Meriones libycus*. In the interior, this species prefers areas of abundant sand and is occasionally taken in areas where large dunes are present; it is never found associated with mesic habitats.

Throughout the range in Libya, these jirds occur together with many species of rodents but most frequently are taken with representatives of *Gerbillus gerbillus*, *Gerbillus pyramidum*, and *Gerbillus amoenus*.

#### *Meriones caudatus amplus*, new subspecies

Holotype. Adult male, skin and skull, USNM 322681, from El Gatrun, Fezzan Province, Libya; obtained Jan. 8, 1962, by G. L. Ranck, original no. 1245.

Specimens examined. Twenty-three, from Fezzan: Meseguin, 8; Traghen, 2; 28 km E Murzuch, 3; El Gatrun, 10 (1 skin only).

Measurements. Averages and extremes of four adult males and measurements of two adult females, 322677 and 322679, all from the

type locality, with the measurements of the type in brackets, are, respectively: Total length 316.8 (302–335), 318, ?, [335]; length of tail 160.8 (151–175), 166, ?, [175]; length of hind foot 38.8 (36–41), 39, 39, [40]; length of ear 21.3 (20–23), 21, 20, [21]; greatest length of skull 42.2 (41.5–42.8), 42.1, 44.3, [42.8]; length of palate 18 (17.5–18.5), 18.2, 17.8, [18.5]; length of audital portion of auditory bulla 16.2 (15.6–16.7), 16.4, 16.7, [16.7]; alveolar length of upper molariform toothrow 5.6 (5.5–5.9), 5.5, 5.9, [5.5]; least interorbital breadth 7.6 (7.5–7.8), 7.1, 7.6, [7.5]; length of nasals 15.9 (15.5–16.2), 15.9, 16.7, [16.2]; breadth of rostrum at level of antorbital foramina 4.1 (4–4.2), 4.1, 4.4, [4.2]; greatest breadth across zygomatic arches 23 (22.2–23.7), 22.5, 22.3, [23.7].

Diagnosis. Upperparts rich, lustrous, normally ranging from Ochraceous-Tawny to Buckthorn Brown and with moderate admixture of blackish-tipped hairs; in some paler specimens, the color of the dorsum approaching Cinnamon-Buff and uniformly colored throughout; long, silky guard hairs projecting 8 to 10 millimeters beyond the level of the underlying pelage, particularly on the rump; sides and scapular areas lightly washed with gray; distinct whitish and buffy patches present above the eyes, between the ears and the eyes, and below and behind the ears; in the pale color phase, these patches almost pure white and contrasting markedly with the surrounding pelage; mystacial, rostral, and circumoral areas ranging from buff to pure white; eye ring black; pinnae of ears long, sparsely haired, and in some specimens, almost naked; prominent row of buffy hairs projecting from the anterior margin of the pinna into the internal surface; vibrissae long, formed largely of white hairs, and sometimes extending posteriorly for 25 millimeters beyond the level of the ears; dorsal surfaces of fore and hind feet pure white; palmar surfaces naked; ventral surfaces of hind feet densely furred but with prominent hairless areas occupying the proximal one-half of the plantar surface; both fore and hind feet with five digits with dark-colored claws; tail exceedingly long for the species, and with a conspicuous black pencil extending over the distal one-third of the dorsal surface and continuing onto the ventral surface for perhaps 25 millimeters; tail unicolorous in the dark color phase, except for some faint suffusions of black hairs dorsally; tail contrastingly bicolored in the pale color phase, Cinnamon-Buff dorsally and almost pure white ventrally; entire underparts usually pure white, but in some specimens, with faint suffusion of buff. Skull: Extremely large, angular, and massive; zygomata strong and robust; auditory bullae markedly inflated both ventrally and laterally; lateral meatal expansions strongly inflated and firmly adpressed to squamous portion of temporal bone; suprameatal triangle small, elliptical in shape, and

completely enclosed by enveloping processes of the temporal and supraoccipital bones.

Comparisons. From representatives of *Meriones caudatus caudatus* from 55 kilometers southwest of Bir Allagh, Tripolitania, the type and paratypes of *M. c. amplus* differ in much larger and more robust crania, particularly the zygomata, larger overall size, and noticeably lighter dorsal pelage with less suffusion of black. *Meriones caudatus amplus* also has proportionately smaller molariform teeth, and the lateral meatal expansion is less closely adpressed to the squamous portion of the temporal bone.

Members of this new subspecies can be easily distinguished from those of *Meriones caudatus confalonierii* from coastal Tripolitania and Cyrenaica by markedly larger and more robust skulls, larger overall size, and paler dorsal coloration.

*Meriones caudatus amplus* can be distinguished from *Meriones caudatus luridus* from the vicinity of Giarabub, Cyrenaica, by larger size of skull and external dimensions, more conspicuous pencil, and darker (less yellowish) dorsal color, particularly that of the tail.

Remarks. In its much larger size, both cranially and in external features, *Meriones caudatus amplus* is clearly distinct from all other subspecies of *Meriones caudatus*. In color, it is closest to *Meriones caudatus caudatus* of the Tripolitanian deserts, although it has much less black on the dorsum. Cranially, this subspecies most nearly resembles *Meriones caudatus luridus* from northeastern Cyrenaica. The latter is also a form of rather large cranial size, but *M. c. amplus* is still significantly larger.

Except for a few specimens representing *Meriones crassus* from Umm el Abid, Zieghen, and the "Serir" of Murzuch, collected by Edward Dodson of the Whitaker Expedition to Tripoli in 1901, the present series constitutes the first record of occurrence of members of this genus from the Fezzan.

Because of larger size, *M. c. amplus* might well be regarded as a distinct species, but because of general resemblance to other subspecies of *M. caudatus* in color, body form, general external characters and in proportions, shape, and configuration of the skull, probably it represents only an extreme in a clinal gradient.

This subspecies shows no evidence of gene exchange with *Meriones caudatus caudatus* to the north. The Gebel es Soda and the barren areas of the Hamada de Tinrhert and Hamada el Hamra apparently restrict interbreeding between populations of these two subspecies. This apparent allopatry has resulted in morphological divergence in the Fezzanese populations, and this subspecies actually may represent an incipient species.

In the Fezzan, these large rodents are known from comparatively few localities. No specimens are available from northern and western Fezzan, although suitable habitat is widespread, particularly in the vicinity of the oases of Sebha, Temenhint, Brach, Edri, El Abiad, Ubari, and Ghat. Future collecting in these areas, however, will probably reveal the presence of these jirds.

The specimens available at present are almost indistinguishable morphologically, which suggests a free interchange of genes within and between populations in the eastern Fezzan. Two distinct color phases, a dark and a light phase, are present among the specimens from Meseguin and El Gatrun; some are intermediate in color. Animals representing all these color types are indistinguishable, however, in cranial characters. Therefore these wide ranges of color types suggest a variable genotype for color and do not indicate basic genetic differences. At present, specimens are too few in number and are from too few localities to allow any generalizations about the full extent of variation among the various populations in the Fezzan.

These jirds from the Fezzan are clearly not closely related to any other subspecies of *M. caudatus* in Libya and probably have closer affinities with populations in southern Algeria, Niger, or the northern Chad.

Ecological observations. These jirds apparently require loose sand for their burrows. At all collecting sites, areas of pure sand or small dunes formed the dominant habitats, and specimens were never taken in areas devoid of sand. At the type locality at El Gatrun, a good series was obtained from the small dunes and sandy areas interspersed among the date palms. Frequently, these large rodents were caught in traps set upon sandy elevations having a dense cover of young palms. Usually in these habitats, large burrows are visible beneath the palms. The collecting sites near Murzuch, Traghen, and Mesequin were all characterized by areas of loose sand associated with densely growing, bushlike date palms.

Apparently they do not occur in the marginal areas of the oases where areas of loose sand and date palms usually are lacking. These marginal habitats are typically hamada-like, and if vegetation is present, it consists of *Tamarix* and *Calligonum* growing upon isolated clay hummocks or sporadic growths of small, succulent plants interspersed on barren playas.

In areas of loose sand, tracks and pathways of these jirds are widespread and usually extensive complexes of burrows are present. On several occasions, specimens were taken from traps set within or near entrances to burrows. Only rarely were traps holding full adults found in position in the trapline. Generally they were found dead several feet distant from the nearest trap, apparently after having been fatally struck.

At El Gatrun some of these jirds were purchased from the Arab inhabitants and had presumably been living commensally with them. This is not surprising in view of the sandy floors and hastily built structures in which these people live.

Jirds are primarily nocturnal, but on one occasion at El Gatrun, an old adult male, 322672, was shot in full daylight while it foraged near the base of a clump of palms.

*Gerbillus pyramidum* is commonly associated with *M. c. amplus* in these sandy habitats but is always much more abundant. The smaller *Gerbillus gerbillus* occurs less frequently with these jirds.

The name *amplus*, from the Latin meaning large or largest, refers to the large size of members of this subspecies.

#### *Meriones caudatus caudatus* Thomas

*Meriones libycus caudatus* Thomas, Ann. Mag. Nat. Hist., ser. 9, vol. 3, p. 267, March 1919 (Tamari-Fergian, Tripolitania, Libya).

Specimens examined. Thirty-four, from Tripolitania: 40 km ENE, Nalut, 2; 5 km N Mizda, 1; 55 km SW Bir Allagh, 19; 5 km E Derg, 6; 2 km SW Hun, 5; Bir Fergian, 1 (skin only).

Measurements. Averages and extremes of five adult males and five adult females from 55 kilometers southwest of Bir Allagh, are: Total length 282 (268–298), 276.8 (270–282); length of tail 141.4 (130–151), 138.8 (135–142); length of hind foot 35.8 (34–38), 33.8 (33–35); length of ear 18.4 (17–19), 17.8 (16–19); greatest length of skull 38.7 (37.5–39.7), 38.3 (37.4–39.5); length of palate 15.6 (15.3–16.1), 15.6 (15.3–16); length of audital portion of auditory bulla 14.7 (14–15.7), 14.8 (14.3–15.4); alveolar length of upper molariform toothrow 5.3 (4.8–5.5), 5.3 (5.2–5.5); least interorbital breadth 7 (6.8–7.1), 6.8 (6.5–7.3); length of nasals 14.7 (13.8–15.4), 14.7 (14.4–15); breadth of rostrum at level of antorbital foramina 4 (3.9–4.1), 3.9 (3.7–4.1); greatest breadth across zygomatic arches 20.9 (19.9–21.7), 20.5 (20–21).

Diagnosis. Pelage of dorsum silky and lustrous with long guard hairs projecting beyond shorter underlying buffy hairs; upperparts Cinnamon-Buff grading to Pinkish Buff on sides and flanks; all parts of dorsum strongly suffused with black, being particularly concentrated on rump; in most specimens, supraorbital and postauricular patches prominent, Pale Pinkish Buff, frequently persisting as indistinct pale areas anterior to pinnae; eye ring black; circumoral and mystacial areas, cheeks, and chin pure white, in some specimens, with faint suffusion of buff; pinna of ear densely furred, same color as dorsum, with distinct row of buffy hairs along anterior margin; dorsal surfaces of fore and hind feet usually pure white, but, in some specimens, with slight suffusion of buff; palmar surfaces naked; plantar surfaces naked proximally, densely furred distally and almost pure white; fore and hind feet each with five digits with claws, the latter

285-134 O—68——12

dark-colored basally and pale-colored distally; vibrissae relatively long, formed from both light and dark-colored individual hairs, and extending well beyond the level of the ears; tail relatively long, dorsal surface about same color as dorsum, but more heavily suffused with black, and ventral surface uniformly Pinkish Buff; prominent black pencil occupies terminal one-third of the dorsal surface of the tail and extends along the ventral surface one-half this distance. Skull: Medium in size; auditory bullae markedly inflated both laterally and ventrally; lateral meatal expansion large and applied to squamous part of the temporal bone; suprameatal triangle small, elliptical, and completely enclosed by enveloping processes of the temporal and supraoccipital; anterior portion of basioccipital and body of basisphenoid reduced to narrow rod-shaped structures between the large bullae.

Comparisons. From topotypes of *Meriones caudatus luridus*, a single topotype of *Meriones caudatus caudatus*, 302246, from Bir Fergian, and near topotypes of *M. c. caudatus* from near Hun, Derg, and Bir Allagh, Tripolitania, differ in having dorsal pelage more heavily suffused with black, shorter tails with more prominent pencils (black rather than brownish) and being significantly smaller in all cranial measurements except the length of the upper molariform toothrow.

When representatives of *M. c. caudatus* are compared with topotypes of *Meriones caudatus confalonierii*, the latter differs in slightly paler color of the dorsum and slightly smaller size of most cranial characters, being comparable in least interorbital breadth and width of rostrum. In general body size animals of the two subspecies are almost indistinguishable. Although the above characters are somewhat tenuous, and *M. c. confalonierii* is poorly defined morphologically, the differences are still sufficient for separating subspecies, and I prefer to regard *M. c. confalonierii* as a valid form.

For comparison with *M. c. amplus*, see account of that subspecies.

Remarks. A single topotype, 302246, from Bir Fergian, 10 kilometers south of Socna, Tripolitania, agrees closely in external measurements and color with the original description of *Meriones libycus caudatus* Thomas (1919, p. 267). Unfortunately, the skull of this single topotype was inadvertently lost, and cranial comparisons are not possible. Cranial measurements of representative series from nearby localities are decidedly smaller than those of the type specimen. I have not examined the type specimen of *Meriones libycus caudatus* (=*Meriones caudatus caudatus*), but judging from the literature, probably it represents an extremely old and outsized male which is not entirely representative of this subspecies.

The various populations of this subspecies in Tripolitania are rather uniform in cranial characters, but some local variation is present in

dorsal color. Two specimens from near Nalut, 321833 and 321834, are the darkest dorsally of any of the Libyan populations of this subspecies and have more orange on the dorsal surface of the tail. Specimens from Derg, 321842, and Mizda, 321862, are noticeably paler dorsally than other representatives of this subspecies.

Judging from the morphological homogeneity within and between the various populations, these jirds must interbreed freely throughout their range in Tripolitania. The vast expanses of the Hamada el Hamra and the rugged escarpments of the Gebel Nefusa have proved ineffective as deterrents to dispersal of this subspecies. To the northeast, however, the more humid coastal areas apparently provide unsuitable habitats, and to the south, the Hamada de Tinrhert and Gebel es Soda have retarded or entirely prevented gene exchange with the Fezzanese populations. Specimens are not available from localities between the ranges of *M. c. caudatus* and *M. c. confalonierii* to the northeast and *M. c. amplus* to the south; however, when specimens do become available from these areas, they probably will show intergradation between *M. c. caudatus* and these contiguous subspecies.

Ecological observations. These jirds are unknown from localities outside Tripolitania but have disjunct distribution throughout the hamadas and oases of the interior. Their range includes the inner portions of the broad coastal plain of northwestern Tripolitania. The climate and terrain here are not unlike those of the inland deserts and generally are not typical of the coastal plain.

In Tripolitania, representatives of this subspecies were collected from a wide variety of habitats as follows: Nalut: Localized, vegetated dunes supporting *Calligonum* and bushy, thorny perennials. Numerous burrows were present throughout the trapline, most of which were probably made by gerbils. Mizda: Occasional mounds and hard elevations in the bottom of a badly eroded wadi. The vegetative cover consisted primarily of two species of thornbush growing among the hummocks. Bir Allagh: An isolated concentration of sandy-clay hillocks supporting thornbush in the midst of otherwise barren hamada. Derg: Margins and bottom of a shallow wadi with occasional hillocks of sand interspersed with denuded rock-strewn areas. Most of the trap settings were made near the entrances of active burrows. Hun: Large, localized permanent mounds supporting almost impenetrable growths of a thorny perennial in the midst of an extensive sandy plain.

These rodents are normally nocturnal, but near Hun, a subadult specimen was caught in full daylight only a few seconds following the setting of the trap.

At the various collecting sites in Libya, they occurred with *Meriones libycus; Gerbillus aureus; Jaculus jaculus; Gerbillus campestris; Jaculus*

*deserti; Pachyuromys duprasi; Gerbillus gerbillus; Gerbillus pyramidum; Gerbillus amoenus; Gerbillus eatoni;* and *Acomys cahirinus.*

#### *Meriones caudatus confalonierii* de Beaux

*Meriones libycus confalonierii* de Beaux, Ann. Mus. Stor. Nat. Genova, vol. 55, p. 384, 1931 (El Agheila, Cyrenaica Province, Libya).

Specimens examined. Seven, from Cyrenaica: 5 km W El Agheila, 5; from Tripolitania: 15 km WNW Marble Arch, 2.

Measurements. Measurements of an adult male, 302229, and averages and extremes of four adult females from 5 kilometers west of El Agheila, are, respectively: Total length 277, 280.5 (277–284); length of tail 143, 146.5 (145–148); length of hind foot 34, 34.5 (34–36); length of ear 18, 18.3 (18–19); greatest length of skull 36.4, 36.8 (36–37.4); length of palate 15.3, 15.1 (14.2–15.8); length of audital portion of auditory bulla 13.9, 14.4 (13.7–15); alveolar length of upper molariform toothrow 4.9, 5.1 (5–5.3); least interorbital breadth 6.4, 6.6 (6.2–6.8); length of nasals 13.5, 13.2 (12.7–13.5); breadth of rostrum at level of antorbital foramina 3.9, 3.8 (3.7–3.9); greatest breadth across zygomatic arches 19.3, 19.8 (19–20.4).

Diagnosis. Identical to that of *Meriones caudatus caudatus* as given in the preceding account, except for the slightly paler dorsal pelage with less suffusion of black and the more brownish color of the pencil. Cranially, *confalonierii* is smaller than *caudatus* in almost all respects but in general salient features of the skull, there are no significant differences.

Comparisons. This subspecies can be easily distinguished from both *Meriones caudatus amplus* of the Fezzan and *Meriones caudatus luridus* from northeastern Cyrenaica by its markedly smaller, more gracile skull and much smaller overall size of body.

For detailed comparison with *Meriones caudatus caudatus*, see under "comparisons" in account of that subspecies.

Remarks. Most of the specimens considered here are topotypes of *Meriones caudatus confalonierii* and agree rather closely with measurements and descriptions as given by de Beaux (1932) in the original description.

Setzer (1957) had seven specimens from El Agheila, two of which he erroneously assigned to *Meriones libycus confalonierii* (=*Meriones caudatus confalonierii*). He also referred a single specimen (skull only, 302311) from Zliten, Tripolitania, to this subspecies. Actually, these three specimens belong to *Meriones libycus auratus* (then *Meriones shawi shawi*) and are specifically different from the other five specimens from El Agheila, which were correctly assigned to *Meriones libycus confalonierii*. The species *M. libycus* and *M. caudatus* thus occur sympatrically at El Agheila.

This coastal subspecies is known from only the type locality at El Agheila, Cyrenaica, and from Marble Arch in Tripolitania. Its range, however, probably includes most of the coastal plain and transitional desert along the Gulf of Sirte as far east as Benghazi. The more mesic uplands of the Cyrenaican Plateau and Gebel Achdar which are interposed between the ranges of this subspecies and that of *Meriones caudatus luridus* to the east, provide unsuitable habitats for these jirds. The coastal plain also is markedly reduced or absent in many places in northern Cyrenaica and serves to further limit the extent of habitats suitable for jirds and tends to reduce gene flow between the two subspecies. There are no physical barriers separating the range of *M. c. confalonierii* from that of *M. c. caudatus* to the south, but apparently the more arid climate farther inland is unsuitable for members of this coastal subspecies. Some intergradation doubtless takes place between these two subspecies somewhere in the transitional desert south of the Gulf of Sirte.

Ecological observations. This subspecies is apparently confined to the more humid habitats of the coastal plain and littoral deserts surrounding the Gulf of Sirte in Cyrenaica and Tripolitania. The two specimens from near Marble Arch were collected from the northernmost terminus of the coastal hamada overlooking the coastal plain. Vegetative cover here was sporadic, localized, and somewhat transitional between that of the more densely vegetated coastal plain and the much sparser plant cover of the hamadas farther inland. Setzer (1957) describes the habitat at El Agheila as consisting of sandy areas with a good vegetative cover. He also observed large, shallow burrows located under bushes and containing from three to eight entrances. Seeds and leaves of locally common plants were found in the burrows.

#### *Meriones caudatus luridus*, new subspecies

Holotype. Adult male, skin and skull, USNM 325597, from Bahr el Tubat, 21 km ESE Giarabub, Cyrenaica Province, Libya; obtained May 29, 1962, by G. L. Ranck, original no. 2187.

Specimens examined. Twenty-nine, from Cyrenaica: 11 km E Ain el Gazala, 2; 10 km SW Fort Capuzzo, 1; 60 km S Bir el Gobi, 17; Giarabub, 2; Bahr el Tubat, 21 km ESE Giarabub, 5; 24 km SSE Giarabub, 2.

Measurements. Measurements of an adult male, 325598, from the type locality, and the measurements of an adult female, 302317, from Giarabub, with the measurements of the type in brackets, are, respectively: Total length 268, 240, [291]; length of tail 131, 123, [155]; length of hind foot 34, 32, [36]; length of ear 18, 17, [19]; greatest length of skull 39, 38.6, [40]; length of palate 16.6, 16, [16.3]; length of audital portion of auditory bulla 14.6, 14.5, [15.3]; alveolar

length of upper molariform toothrow 5.1, 5.1, [5.4]; least interorbital breadth 7.5, 6.4, [7.4]; length of nasals 14.8, 14.5, [15]; breadth of rostrum at level of antorbital foramina 4, 3.6, [3.6]; greatest breadth across zygomatic arches 20.6, 20, [20.5].

Diagnosis. Upperparts subdued in color varying in tones of Ochraceous-Buff, Light Ochraceous-Buff, Warm Buff and Pinkish Buff; all parts faintly washed with gray; postauricular patches distinct, almost pure white; region around eyes light gray strongly suffused with black; cheeks and circumoral areas white; eye ring black; vibrissae long, formed of about equal numbers of black and white hairs; pinna of ear sparsely haired, particularly on medial aspect and with distinct row of buffy hairs along anterior margin; fore feet naked ventrally, buffy-white dorsally and bearing five digits with dark-colored claws; hind feet heavily haired ventrally, except for a prominent hairless area confined to proximal half of plantar surface, white dorsally and also bearing five digits with claws; tail relatively long, unicolorous, slightly paler than that of the dorsum, with prominent black pencil occupying distal one-fourth of dorsal surface and extending a short distance along ventral surface. Skull: Relatively large and robust; zygomata heavy and coarse; anterior palatine foramina narrow and slitlike; auditory bullae large, markedly inflated both ventrally and laterally, and adnate to squamous portion of temporal bone; suprameatal triangle large and completely enclosed by enveloping processes of the supraoccipital and temporal bone.

Comparisons. This new subspecies can be distinguished from both *Meriones caudatus caudatus* of the Tripolitanian deserts and *Meriones caudatus confalonierii* of the Tripolitanian and Cyrenaican coastal plains by its larger body size, being larger in all cranial measurements except breadth of rostrum, alveolar length of upper molariform toothrow, and zygomatic breadth. In external measurements, *Meriones caudatus luridus* is larger in greatest length and length of tail but of comparable length in the length of hind foot and ear.

Although animals belonging to *M. c. luridus* are of large size, they still differ strikingly from *M. c. amplus* in having smaller and more gracile crania, particularly the zygomata, and smaller external measurements.

In its markedly paler, more yellowish dorsal color, particularly that of the tail, and in the less conspicuous pencil, this subspecies differs strikingly from all other subspecies of *Meriones caudatus*.

Remarks. Toschi (1951 and 1954) assigned specimens from the vicinity of Giarabub to *Meriones libycus libycus* and *Meriones libycus caudatus*. Sympatry of two subspecies of the same species is not in accordance with modern systematic and evolutionary concepts. In the present work, however, *M. libycus* and *M. caudatus* are considered

as separate species, and the above mentioned sympatry is to be expected.

I have not examined Toschi's specimens, but judging from his measurements, they most likely belong to *Meriones caudatus luridus* and not to *Meriones libycus libycus*. This does not preclude the possibility that the latter species occurs at Giarabub. Representatives of both species occur sympatrically along the northern Cyrenaican coast and doubtless are sympatric throughout coastal Egypt.

One specimen of *M. c. luridus*, 325586, from 11 kilometers east of Ain el Gazala on the northern Cyrenaican coast is almost identical in color to topotypical *Meriones caudatus confalonierii* from near El Agheila farther west in Libya. This is the only evidence of intergradation with populations of *M. caudatus* to the west. The high tablelands of the Cyrenaican Plateau, the massif of the Gebel Achdar, and the marked reduction of the coastal plain apparently act as deterrents to gene flow between members of this subspecies and those farther west. *Meriones caudatus luridus* probably has greater affinities with jirds in western Egypt. Its range probably includes Giarabub Oasis and all of the inland hamadas south of the Cyrenaican Plateau in Libya, the Libyan Plateau of extreme northwestern Egypt, and the extensive low-lying areas of Siwa Oasis, the Qattara Depression, and the Wadi Natroun in Egypt. The barren vastness of the Serir of Calanscio and the Sand Sea of Calanscio, in Libya, and the desolate Western Desert in Egypt apparently limit the southward distribution of these jirds.

This subspecies is known from comparatively few specimens and the full extent of its variation is unknown. Two specimens, 302316 and 302317, from Giarabub, however, are noticeably more orangish in dorsal color and lack the typical yellowish-buff color of the tail. A large series from south of Bir el Gobi, most of which are subadults, are constant in showing this pale yellowish dorsal color.

Ecological observations. In Libya, this subspecies is confined primarily to the hamadas and sandy deserts of the interior, but the collecting sites 11 kilometers east of Ain el Gazala and 10 kilometers southwest of Fort Capuzzo are less than 15 kilometers from the Mediterranean coast. In coastal areas, members of this subspecies occur together with those of *Meriones libycus*. The extent of the range of the latter species farther inland has not yet been ascertained, but the two species are probably sympatric throughout all of northeastern Libya and northwestern Egypt.

These jirds have similar habitat preferences to populations of *M. c. caudatus* and *M. c. confalonierii* in western Libya, all having a decided predilection for sandy areas. The habitats at the following localities in Cyrenaica are characterized as follows: 11 km E Ain el

Gazala: Series of vegetated sandy-clay hummocks near the roadside, many of which contained large open burrows. Most burrows were littered with plant debris and remnants of seeds. This site was situated on the extreme northern terminus of the coastal hamada and approximately five kilometers from the Mediterranean Sea. 10 km SW Fort Capuzzo: A localized pocket of bushes and smaller perennials surrounded by almost barren hamada. Burrows were widespread in the coarse, sandy soil. 60 km S Bir el Gobi: Localized pockets of vegetation bordering the sandy margins of a small wadi in the midst of an otherwise featureless and totally barren "serir." 24 km SSE Giarabub: Residual sandy-clay hummocks and lesser dunes interspersed in areas of loose sand in the bottom of a broad, enclosed wadi. Bahr el Tubat: Extensive concentrations of large vegetated dunes. At the latter two collecting sites, *Gerbillus gerbillus*, *Jaculus jaculus*, and *Gerbillus campestris* were taken along with these jirds.

The subspecies name *luridus*, from the Latin meaning pale yellow or yellowish, alludes to the pale-yellow tones of the dorsal pelage.

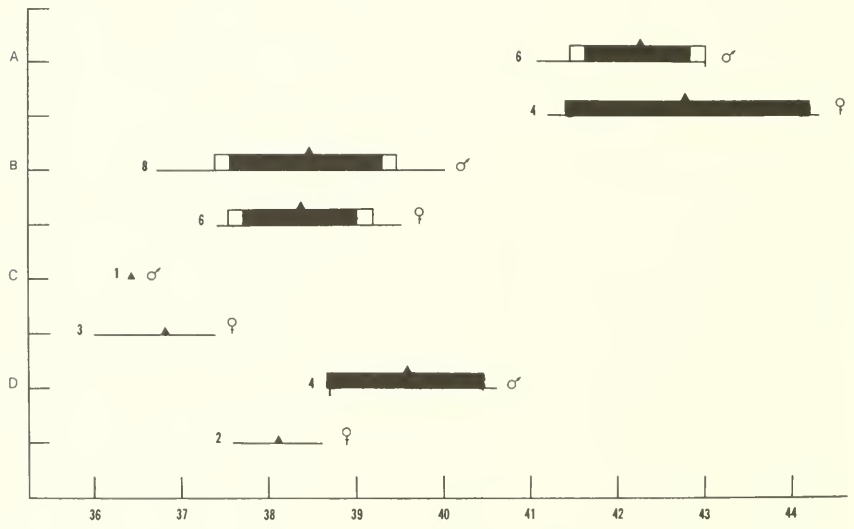


FIGURE 38.—Statistical comparison of greatest length of skull of the subspecies of *Meriones caudatus:* A, *M. c. amplus;* B, *M. c. caudatus;* C, *M. c. confalonierii;* D, *M. c. luridus.*

### *Meriones crassus tripolius* Thomas

*Meriones pallidus tripolius* Thomas, Ann. Mag. Nat. Hist., ser. 9. vol. 3, p. 265, March 1919 (Gebel Limhersuk, in the northwest part of the country).

GENERAL DISTRIBUTION OF SPECIES. West Pakistan, Afghanistan, southern Russian Turkestan, Iran, Iraq, Syria, Lebanon, Jordan, Israel, Saudi Arabia, Egypt (including Sinai), Libya, Algeria, and

the northern Sudan. The range probably also includes portions of Mauritania, Niger, and the Chad.

Distribution in Libya. Interior deserts of Tripolitania and the Fezzan; currently unknown from Cyrenaica, but probably occurs here also.

Specimens examined. Twenty-four, from Tripolitania: Gebel Limhersuk, 3 (BM); 5 km S Socna, 4; Bir Fergian, 4 (BM; 2 skin only); from Fezzan: Brach, 1; Edri, 1; 26 km N Goddua, 1; 75 km W Ubari, 4; 55 km SSW Serdeles, 2; 20 km N Ghat, 2; 12 km N Ghat, 2 (one skull only).

Published records in Libya. Cyrenaica: Sidi Sweya (Thomas, 1902); Tripolitania: Wadi Agarib, Koshebey, Gebel Limhersuk (Thomas, 1902 and 1919 [*Meriones schousboei* Loche and *Meriones pallidus tripolius*]); Fezzan: Umm el Abid, Murzuch, Zieghen (Thomas, 1902); Bir el Fatia, Serdeles (Toschi, 1951).

Measurements. Measurements of two adult males, 322660 and 322662, and one adult female, 322659, from 75 kilometers west of Ubari, Fezzan, are, respectively: Total length 232, 232, 235; length of tail 114, 121, 121; length of hind foot 31, 30, 30; length of ear 17, 17,

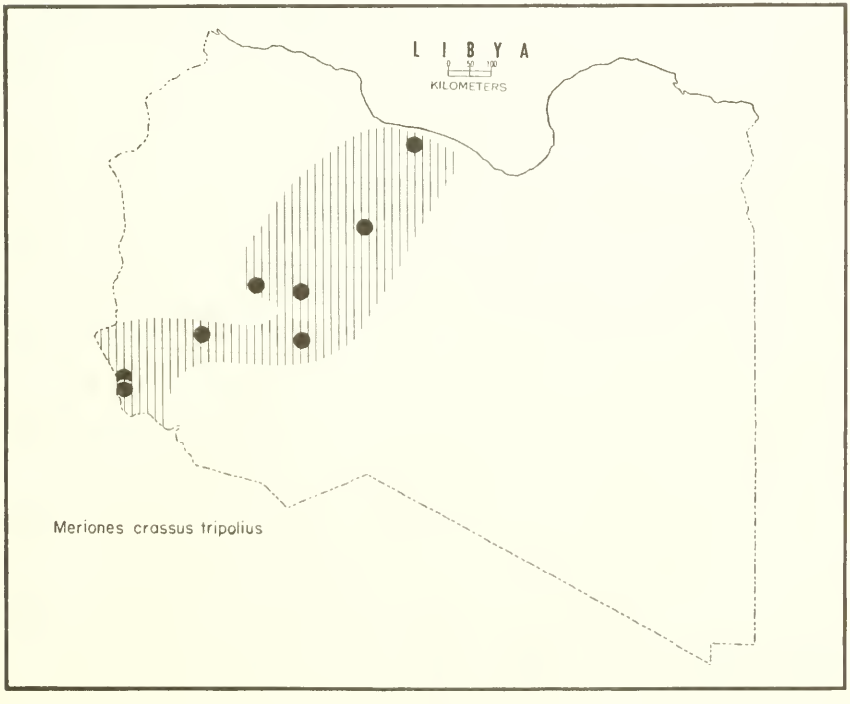


Figure 39.—Distribution of *Meriones crassus tripolius*.

18; occipitonasal length of skull 36.5, 35.9, 35.5; length of palate 15, 15.2, 15.1; length of anterior palatine foramina 6.1, 5.7, 5.7; length of audital portion of auditory bulla 14.3, 13.8, 14.4; alveolar length of upper molariform toothrow 5.3, 5.7, 5.2; least interorbital breadth 5.7, 5.9, 5.8; length of nasals 13.4, 13.6, 13.6; greatest breadth across zygomatic arches 19.8, 19.3 19.9; breadth of rostrum at level of antorbital foramina 3.1, 3.4, 3.4.

Diagnosis. Pelage of dorsum fine, silky and lustrous; varying in color from Light Ochraceous-Buff and Cinnamon-Buff to Pinkish Cinnamon; most specimens with mild admixtures of brown-tipped hairs on dorsum, which produce a slightly streaked or marbled appearance; sides, supraorbital, preauricular, and subauricular regions with faint suffusions of gray; eye ring black or dark brown; circumoral and mystacial areas, and conspicuous postauricular patches Pinkish Buff; pinna of ear densely haired, about same color as dorsum, and with distinct row of buffy hairs along anterior margin; vibrissae long, formed of black and white individual hairs; forefeet almost pure white dorsally, naked ventrally and with five digits bearing pale-colored claws; hind feet usually white dorsally, with thick covering of hairs ventrally, except for conspicuous hairless areas on proximal halves of plantar surfaces, and also with five digits bearing pale-colored claws; tail relatively short for the species, Pinkish Buff in color, appearing bicolored owing to slight admixture of black hairs dorsally, and with distinct brush of black or dark brown hairs distally. Skull: Relatively small and gracile for the species; auditory bullae large and bulbous, noticeably inflated ventrally, laterally, and posteriorly, but to a lesser extent than in other subspecies; lateral meatal expansion closely applied to squamous portion of temporal bone; suprameatal triangle large, triangulariform, and imperfectly closed posteriorly by enveloping processes of the supraoccipital and temporal bones.

Comparisons. From representatives of *Meriones crassus crassus* Sundevall from the vicinity of Feiran Oasis and St. Catherine's Monastery, Sinai, Egypt, paratypes of *Meriones crassus tripolius* from Tripolitania and representatives of *M. c. tripolius* from various localities in the Fezzan differ in darker dorsal color, shorter and less inflated auditory bullae, less robust zygomata, and generally much smaller size of cranium and all external dimensions.

Compared to representatives of *Meriones crassus pallidus* Bonhote from the Eastern Desert Governorate, Egypt, *M. c. tripolius* differs in the same characters as given for *M. c. crassus*. Adult specimens of *M. c. asyutensis* Setzer are not available for comparison, but judging from the original description (Setzer, 1961), they are significantly

larger than those of *M. c. crassus* and, by inference, must be markedly larger than those of *M. c. tripolius* in every detail.

*Meriones crassus* can be distinguished easily from both *Meriones libycus* and *Meriones caudatus* by larger and more posteriorly inflated auditory bullae, larger suprameatal triangles with open posterior processes rather than closed or closely approximating as in *M. libycus* and *M. caudatus*, shorter tail, and generally paler, more uniform dorsal color.

Remarks. Setzer (1961) described *Meriones crassus perpallidus* from Cairo-Alexandria Road, 4 kilometers from Cairo, Egypt, and stated that it differed from representatives of *Meriones crassus tripolius* by paler dorsal color, larger, more massive skull, wider, shorter rostrum, and more posteriorly inflated auditory bullae. When paratypes of these two subspecies are compared, however, *M. c. tripolius* can be most easily distinguished from *M. c. perpallidus* by darker dorsal color, with stronger suffusion of brownish hairs, and by markedly smaller size of external dimensions. Paratypes of *M. c. tripolius* also have slightly larger and more massive skulls, rather than smaller skulls as stated by Setzer, and the mastoidal portion of the auditory bulla is less inflated posteriorly. The breadth and length of the rostra do not differ appreciably in paratypes of *M. c. tripolius* and *M. c. perpallidus*.

When Setzer described *M. c. perpallidus*, he had only a few specimens of *M. c. tripolius* from Tripolitania and apparently did not examine typical specimens of *M. c. tripolius* from the Gebel Limhersuk. In the present work, paratypes of both subspecies are at hand, some additional characters by which these two subspecies differ are noted, and some of the differences set forth by Setzer are not apparent.

Thomas (1902) assigned specimens obtained by Edward Dodson in 1901 from several localities in Tripolitania and the Fezzan to *Meriones schousboei* Loche. In a later paper (1919), using these same specimens, he described *Meriones pallidus tripolius* (=*Meriones crassus tripolius*) with the type locality at Gebel Limhersuk, Tripolitania, and named *Meriones libycus caudatus* from Tamari-Fergian, Tripolitania. He did not ascribe a specific range to either species, however, and in no way indicated to which of the above species the specimens from the Fezzan might be referred. Many years later, Chaworth-Musters and Ellerman (1947) assigned these Fezzanese specimens to *Meriones crassus*.

Since Thomas described *Meriones pallidus tripolius* (=*Meriones crassus tripolius*) in 1919, this subspecies has had an uncertain status. It was first treated as a subspecies of *Meriones libycus* (Ellerman, 1941), later considered as a subspecies of *Meriones crassus* (Ellerman, 1947 and Chaworth-Musters and Ellerman, 1947), and finally regarded as

a synonym of *Meriones crassus crassus* (Ellerman and Morrison-Scott, 1951 and Toschi, 1954). More recently, Setzer (1957) reinstated *M. c. tripolius* as a valid subspecies of *M. crassus* and assigned specimens from near Socna and Bir Fergian, Tripolitania, to it. He stated that these jirds from Libya were markedly paler and had smaller skulls with particularly less inflated posterior portions of the auditory bullae than typical specimens of *M. c. crassus* from Sinai. Thomas (1919), in the original description of *Meriones pallidus tripolius*, said that it was very near to *Meriones pallidus* (=*Meriones crassus pallidus*), of the Sudan, but with smaller auditory bullae and slightly darker dorsal color.

Throughout the known range in Libya, populations of these jirds are remarkably uniform in cranial characters and dimensions. Jirds from several localities in the Fezzan clearly belong to this subspecies but differ from topotypes of *M. c. tripolius* from farther north in Tripolitania in having slightly more gracile skulls, more delicate zygomata, and in being slightly smaller in external dimensions. In color, all Libyan representatives of this subspecies are inseparable. Two specimens, a very old male (BM, no. 34.8.2.64) and an old female (BM, no. 34.8.2.65) from El Golea, Algerian Sahara, are comparable in color and external measurements to the specimens from Libya but are noticeably larger cranially. This larger size of the Algerian specimens may result from increased angularity and thickening of the skull attributable to extreme old age.

Ecological observations. In Libya, these jirds are represented by comparatively few specimens from Tripolitania and the Fezzan and are unknown from Cyrenaica. Several days of intensive trapping at the oases of Brach and Edri in the Fezzan produced only two specimens, both from the hamada-like plains several kilometers distant from the palm groves and sand of the oases proper. Near Ghat and Ubari they inhabited the margins of shallow wadis that dissected the desolate, flat hamada. At all these collecting sites, vegetative cover was reduced to occasional bunches of dry grasses and scattered acacias. One evening in January, while I camped on the barren plain 26 kilometers north of Goddua, Fezzan, a single male specimen, 322693, was captured alive when it approached to within a few feet of the lantern. Visible vegetation at this campsite was entirely lacking except for a distant solitary acacia tree. These hardy rodents seem to prefer the more barren hamadas and sparsely vegetated wadis located some distance from oases and were never collected from dunes or sandy areas within palm groves. In the latter habitats, however, the larger, more bushy-tailed *Meriones caudatus* is rather common. Because of their preference for these marginal habitats, specimens of *M. crassus* are obtained only rarely and are poorly

represented in collections. The present series probably provides a very incomplete picture of their actual distribution in Libya. The jirds obtained by Edward Dodson, plus additional specimens from Bir el Fatia and Serdeles (Toschi, 1951), those obtained by Setzer (1957) from near Socna and Bir Fergian, and the present series collected by the author from the Fezzan constitute the only known records of occurrence of *Meriones crassus* in Libya.

### *Meriones libycus* Lichtenstein

*Meriones libycus* Lichtenstein, Verzeich. Doubl. Zool. Mus. Berlin, p. 5, no. 9, 1823 (Lichtenstein gives the type locality as "e deserto libyco," but Ellerman and Morrison-Scott [1951:644] limit the type locality to "Near Alexandria.")

General distribution of species. Russian Turkestan, Chinese Turkestan, Transcaucasia, Kara-Kum, Kizil-Kum, Iran, Baluchistan (West Pakistan), Afghanistan, Iraq, Syria, Israel, Saudi Arabia, Sinai, Egypt, Libya, Tunisia, Algeria, and Morocco.

Distribution in Libya. Coastal plain and littoral deserts of Cyrenaica and Tripolitania.

Distribution of the subspecies in Libya.

*Meriones libycus azizi.* Cyrenaica: Coastal areas of extreme northern Cyrenaica.

*Meriones libycus auratus.* Cyrenaica and Tripolitania: Coastal plain of Gulf of Sirte and Tripolitania as far inland as the coastal escarpment.

Published records in Libya. Cyrenaica: Bou Cheifa (Thomas, [*Meriones shawi shawi*] 1902); Benghazi, Gheminez (Festa [*Meriones guyoni* Loche], 1921); Giarabub and vicinity (de Beaux, 1928); Augila (de Beaux [*Meriones guyoni*], 1932); Derna (Zavattari, 1934); Merg (=Barce) (de Beaux, [*Meriones shawi shawi*] 1938); Benghazi, Gheminez (Toschi, [*Meriones shawi shawi*] 1951); Tripolitania: Wadi Aggar, Wadi Nefed, Tarhuna (Thomas, [*Meriones shawi shawi*] 1902).

Comparisons. This species can be readily distinguished from *Meriones crassus* by coarser, less silky fur, markedly smaller and less inflated auditory bullae, and smaller suprameatal triangles with more closely approximating posterior processes.

From a single specimen (MNHN, no. 704) of *Meriones shawi*, as known from Guelt es Stel, Algeria, and two specimens (BM, nos. 60.8.25.12 and 60.8.25.13) identified as *Meriones robustus* Wagner (=*Meriones shawi* [Loche, 1867]) from an unknown locality in Algeria, representatives of *M. libycus* from Libya and Egypt are noticeably smaller cranially and have proportionately larger and more inflated auditory bullae. In color and external measurements, the specimen from Guelt es Stel is similar to representatives of *M. libycus* in Libya.

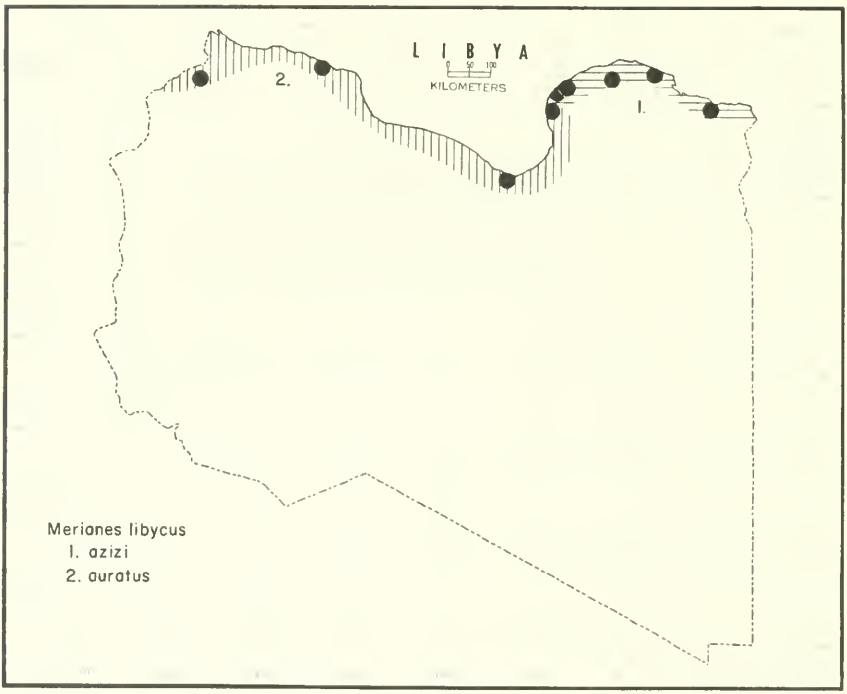


FIGURE 40.—Distribution of the subspecies of *Meriones libycus*.

The other two specimens representing *Meriones robustus* are much darker and markedly larger in all external characters.

Compared to *Meriones caudatus, Meriones libycus* differs in having a markedly shorter tail with a less conspicuous pencil of brown rather than black, smaller and less inflated auditory bullae, and suprameatal triangles which are usually more nearly round in shape, rather than elliptical, and imperfectly enclosed rather than completely enclosed by enveloping processes of the supraoccipital and temporal bones.

REMARKS. Thomas (1902) referred specimens from various localities of coastal Libya to *Meriones shawi*. More recently, Toschi (1954) and Setzer (1957) also considered specimens from coastal Cyrenaica and Tripolitania as subspecies of *M. shawi*. Setzer had no specimens of *shawi* for comparison, and the above assignments were based largely on the similarities of measurements between the Libyan specimens and those of typical *M. shawi*. I have examined those specimens available to Setzer and additional series from other coastal localities in Libya and find them all referable to *M. libycus* of Egypt. These Libyan populations differ slightly from typical *M. libycus* from the vicinity of the Nile and western coastal Egypt, but these differences

are subtle, being typical of subspecies and not of species. In my opinion, specimens from coastal Libya, formerly referred to *M. shawi*, actually belong to *M. libycus*, and if *M. shawi* is a valid species, its range is limited to Algeria and areas to the south and west.

This species is represented in Libya by two subspecies, *Meriones libycus auratus* and *Meriones libycus azizi*. As presently understood, its range in Libya is limited to the Mediterranean littoral as far inland as the coastal escarpment. Apparently the range of the nominate subspecies does not include Libya. Specimens from Sidi Barrani, Salum, and Mersa Matruh of western coastal Egypt, although geographically not far removed from the type locality of *M. l. azizi*, are clearly referable to *M. l. libycus*.

#### *Meriones libycus auratus*, new subspecies

Holotype. Adult male, skin and skull, USNM 302233, from Gheminez, Cyrenaica Province, Libya; obtained Oct. 29, 1955, by H. W. Setzer, original no. 2672.

Specimens examined. Sixteen, from Cyrenaica: Gheminez, 9; 5 km W El Agheila, 2; from Tripolitania: 12 km W Zliten, 3 (1 skull only; 1 skin only); 40 km ENE Nalut, 2.

Measurements. Averages and extremes of four adult males and three adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 273.5 (269–282), 266.5 (260–273), [269]; length of tail 138 (135–143), 133.5 (132–135), [137]; length of hind foot 34 (33–35), 32.7 (32–34), [35]; length of ear 16.8 (16–18), 16 (15–17), [16]; greatest length of skull 37.5 (36.5–38.2), 36.5 (36.2–36.8), [37.1]; length of palate 16.5 (16.3–16.7), 16.2 (16.1–16.3), [16.3]; length of audital portion of auditory bulla 13.3 (12.8–13.4), 12.6 (12.3–12.8), [13]; alveolar length of upper molariform toothrow 5.6 (5.4–5.7), 5.5 (5.3–5.6), [5.6]; least interorbital breadth 6.2 (5.7–6.7), 5.9 (5.7–6.2), [6.1]; length of nasals 14.3 (13.7–14.9), 13.7 (13 6–13.9), [14.9]; breadth of rostrum at level of antorbital foramina 3.6 (3.5–3.8), 3.6 (3.4–3.7), [3.6]; greatest breadth across zygomatic arches 20.5 (19.8–21.4), 19.9 (19.5–20.3), [20.5].

Diagnosis. Upperparts ranging from Buckthorn Brown to Clay Color, becoming paler on sides and approaching Cinnamon-Buff; all of dorsum, including tail, evenly suffused with brownish-tipped hairs; postauricular patches conspicuous and almost pure white; supraorbital and preauricular patches conspicuous and almost white with strong admixture of black-tipped hairs; distinct white patch present on rostrum immediately behind origin of vibrissae; eye ring black; pinna of ear relatively short, remarkably uniform in color, but slightly darker distally and almost devoid of hair, except for a distinct row of posteriorly directed buffy hairs on anterolateral margin; vibrissae fine in

texture, formed of both brown and white hairs, and extending caudad beyond the level of the ears; scapular regions, upper arms, and pectoral areas with moderate suffusions of buff; forefeet white dorsally, almost naked ventrally, and with five digits bearing claws; hind feet white dorsally and with five digits bearing dark-colored claws; plantar surfaces heavily furred except for a small naked area on the ventral surface of the heel; tail, dorsally, approaching color of body and heavily suffused with brown-tipped hairs, and ventrally near Pale Pinkish Buff; a distinct brownish pencil occupying the distal one-fourth of the dorsal surface of the tail. Skull: Relatively small in size, auditory bullae short and well inflated ventrally; anterior palatine foramina relatively narrow; meatal expansion of auditory bullae with abrupt curvature and not applied to the squamous process of the temporal bone; suprameatal triangle rounded and with posterior processes imperfectly closed.

Comparisons. The type series of *Meriones libycus auratus* can be easily distinguished from near topotypes of *Meriones libycus libycus* from the West Desert region of Egypt by markedly smaller and less robust crania, smaller overall size, especially the small size of the hind feet, and noticeably paler, more golden dorsal color.

Members of this subspecies resemble rather closely those of *Meriones libycus azizi* from farther north and east in Cyrenaica but differ in having larger hind feet, wider interorbital breadths and rostra, and paler, more golden dorsal pelage with more prominent postauricular and supraorbital patches.

Remarks. Representatives of this subspecies throughout coastal Libya are remarkably uniform in color and cranial characters. Two specimens, 321835 and 321836, from 40 kilometers east-northeast of Nalut on the Tripolitanian coastal plain are almost indistinguishable from those from the type locality in Cyrenaica, and specimens from El Agheila on the southern margin of the Gulf of Sirte do not differ appreciably from topotypes of *M. l. auratus*. This morphological homogeneity is the result of constant genetic exchange within and between populations of these jirds rendered possible by the almost uninterrupted continuity of suitable habitat of the Cyrenaican and Tripolitanian coastal plains.

Setzer (1956) referred two specimens from El Agheila and a single specimen from near Zliten to *Meriones libycus confalonierii* (=*Meriones caudatus confalonierii*). These three specimens are specifically different from the other specimens found in these localities and clearly belong to *Meriones libycus auratus*. Regardless of their taxonomic status at that time this erroneous assignment is unaccountable as the two forms are easily separable: in the field, by the more bushy tail with prominent black pencil of *M. caudatus* and in the laboratory, by

the noticeably larger and more inflated auditory bullae and complete closure of the suprameatal triangles of *M. caudatus*.

Ecological observations. These jirds apparently prefer areas of low elevation on the coastal plain and are unknown from the higher Saharan interior where they are supplanted by the bushy-tailed *Meriones caudatus*.

At Nalut, two specimens, 321835 and 321836, were obtained from some large dunes near the coastal escarpment. These dunes supported a sparse vegetative cover of *Calligonum* and thorny perennials. Two specimens of *M. caudatus* and a large series of *Gerbillus aureus* were taken from the same trapline. According to Setzer (1957), the habitat at Gheminez and Zliten consisted of poorly vegetated rocky-clay type of soil and fallow barley fields.

Although this subspecies is known from comparatively few specimens and has been collected from only four localities, it doubtless has a wide distribution and is probably sympatric with practically all other species of coastal rodents throughout the Mediterranean littoral of Libya. From the vicinity of El Agheila, it has been taken with *Gerbillus eatoni*, *G. gerbillus*, *G. pyramidum*, *G. amoenus*, *G. henleyi*, *Pachyuromys duprasi*, *Meriones caudatus*, and *Psammomys obesus*. At Gheminez, *Jaculus orientalis*, *Allactaga*, *tetradactyla*, and *Gerbillus aureus* occur with *M. l. auratus*.

The subspecific name *auratus* is derived from the Latin "aurum," meaning gold or of gold, and has reference to the golden cast of the dorsal pelage in members of this subspecies.

### *Meriones libycus azizi* Setzer

*Meriones shawi azizi* Setzer, Proc. Biol. Soc. Wash., vol. 69, pp. 205–206, Dec. 31, 1956 (5 km SE Derna, Cyrenaica, Libya).

Specimens examined. Twenty, from Cyrenaica: 3 km E. Derna, 1; 5 km SE Derna, 2; 7 km E Maraua, 1; 2 km N Coefia, 5; 8 km N Benghazi, 2; 20 km E Tobruch, 9.

Measurements. Measurements of two adult females, 302243 and 325604, from 5 km SE Derna and 20 kilometers east of Tobruch are, respectively: Total length 259, 252; length of tail 131, 123, length of hind foot 32, 31; length of ear 17, 19; greatest length of skull 36.8, 36.4; length of palate 16.4, 16.5; length of audital portion of auditory bulla 12.3, 12.8; alveolar length of upper molariform toothrow 5.6, 5.7; least interorbital breadth 6.1, 5.7; length of nasals ?, 13.7; breadth of rostrum at level of antorbital foramina 3.2, 3.7; greatest breadth across zygomatic arches 20.4, 20.6.

Diagnosis. Upperparts ranging from Snuff Brown to Buffy Brown becoming paler on sides and flanks and approaching Tawny-Olive; all of dorsum strongly suffused with blackish-brown hairs resulting

in a uniformly variegated appearance; circumoral and rostral areas grading from Pinkish Buff to Cinnamon-Buff; area between ears and eyes washed with gray and appearing as a faint patch above the eye; scapular and pectoral areas, chin and upper surfaces of front legs and feet suffused with varying amounts of Pinkish Buff and Light Pinkish Cinnamon; forefeet sparsely haired ventrally with five digits bearing dark-colored claws. Hind feet Pale Pinkish Buff dorsally, richly haired ventrally except for a bare area near the heel, and with five digits with dark-colored claws; pinna of ear moderately haired, becoming darker distally and approaching Saccardo's Umber, with a conspicuous row of buffy hairs along entire anterolateral surface; eye ring black; vibrissae formed of both black and white hairs and projecting backward to the level of the ears; tail Cinnamon and appearing somewhat bicolored owing to strong admixtures of blackish hairs dorsally and with a distinct black pencil confined to the dorsal surface for about the distal one-fourth. Skull: Small in size; auditory bullae short and expanded ventrally; zygomatic arches wide; anterior palatine foramina wide; suprameatal triangles round in shape with posterior processes imperfectly closed.

Comparisons. From near topotypes of *Meriones libycus libycus* from various localities in western coastal Egypt, the type specimen and a paratype of *Meriones libycus azizi* have significantly smaller cranial and external measurements and shorter and more inflated auditory bullae. In color, the two subspecies are quite similar.

For comparison with *Meriones libycus auratus*, see account of that subspecies.

Remarks. The specimens from near Coefia and Benghazi are all immature, but in having distinct postauricular spots and slightly paler dorsal color, they suggest intergradation with *M. l. auratus* to the south and west.

An adult female, 325604, from 20 kilometers east of Tobruch is noticeably paler and more grayish in dorsal color and has a more reduced pencil than the two specimens from the type locality. In these characters, this specimen resembles neither typical *M. l. libycus* nor *M. l. azizi*, but because of its small cranial and body size and the geographic position of the collecting locality, it is here included with the latter subspecies.

With the exception of a single specimen from near Maraua, this subspecies is known only from the Mediterranean littoral of northern Cyrenaica. In these coastal areas, members of this subspecies occur with *Meriones caudatus*, *Jaculus orientalis*, *Jaculus deserti*, *Gerbillus eatoni*, and several species of dipodil gerbils.

## Genus *Psammomys* Cretzschmar

In the past, the taxonomy of the genus *Psammomys* has been almost constantly in a state of confusion. Thomas (1902) was the first to report on representatives of this genus from Libya and described *Psammomys tripolitanus* as a new species based on specimens from Bou Cheifa, Wadi Aggar, and Wadi Cheggar of northern Tripolitania. He assigned specimens, which were much smaller in size and paler in color, from Bu Ngem and the Wadi Wagis, Tripolitania, to *Psammomys roudairei* Lataste. The latter species was known from only two immature types (type specimen and cotype) and had previously been regarded by Lataste (1887) as a synonym of *Psammomys obesus* Cretzschmar. Many years later, Thomas (1925) after examining more specimens from near the type locality of *P. roudairei* in Algeria, once again placed *P. roudairei* in the synonymy of *P. obesus* and proposed the name *Psammomys vexillaris* for the small, pale-colored specimens from Bu Ngem and the Wadi Wagis in Libya.

Since that time, *P. tripolitanus* and *P. vexillaris* have been variously regarded as full species (de Beaux, 1932; Zavattari, 1934) or either one or the other regarded as subspecies of *Psammomys obesus* (Ellerman, 1941; Ellerman and Morrison-Scott, 1951; Toschi, 1954). Ellerman and Morrison-Scott, as well as Toschi, considered *P. tripolitanus* as being synonymous with *P. o. obesus* and accorded *P. vexillaris* only subspecific rank under this species. More recently Setzer (1957), after examining two specimens from near El Agheila and Gheminez, Cyrenaica, reinstated *P. tripolitanus* as a subspecies of *P. obesus* and regarded *P. vexillaris* as a full species, based upon a single specimen from Wadi Bey about 45 kilometers west of Bu Ngem, Tripolitania. He considered the two forms as specifically distinct on the basis of the following characters of the skull of *P. vexillaris:* Supraorbital bead absent, temporal ridges markedly reduced, and molars relatively as well as absolutely larger than in *P. o. obesus.*

In addition to the above characters established by Setzer, this specimen from near Bu Ngem differs strikingly from topotypes of *Psammomys obesus obesus* from the Nile Delta in its much smaller overall size, less robust and more gracile skull, proportionately larger suprameatal triangles, more ventrally inflated auditory bullae, and less developed parietal crests and postorbital processes. In color and external characters, *P. vexillaris* differs markedly in having a much shorter tail with a less extensive pencil, grayish rather than blackish pinnae, greater suffusion of white on venter, white rather than strongly buff-colored dorsal surfaces of hind feet, and much paler, more subdued, dorsal color.

I was unsuccessful in obtaining additional specimens of *P. vexillaris*, but after reexamination of the single specimen collected by Setzer from the Wadi Bey, its specific status is unequivocal in my opinion.

### *Psammomys obesus* Cretzschmar

*Psammomys obesus* Cretzschmar, Rüppell Atlas, 58, pl. 22, 1828 (near Alexandria, Egypt).

General distribution of species. Israel, Jordan, Saudi Arabia, Egypt, Sudan, Libya, and Algeria.

Distribution in Libya. Coastal plain and littoral deserts of Cyrenaica and Tripolitania. The range in Libya is doubtless much wider than the few collecting records indicate.

Distribution of the subspecies in Libya.

*Psammomys obesus obesus*. Cyrenaica: Coastal plain of northeastern Cyrenaica.

*Psammomys obesus tripolitanus*. Cyrenaica and Tripolitania: Coastal plain and littoral deserts of the Gulf of Sirte.

Published records in Libya. Cyrenaica: Bou Cheifa (Thomas, 1902 [*Psammomys tripolitanus*]); El Agheila (de Beaux, 1932 [*Psam-*

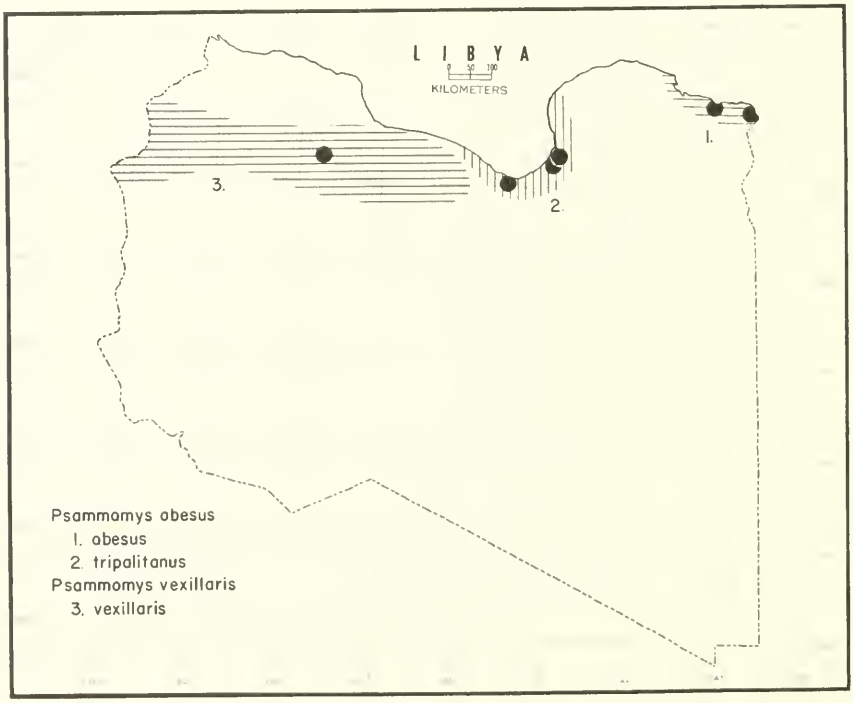


Figure 41.—Distribution of *Psammomys obesus* and *Psammomys vexillaris*.

*momys tripolitanus*]); Zauia Mechili (de Beaux, 1938 [*Psammomys tripolitanus*]); TRIPOLITANIA: Wadi Aggar, Wadi Cheggar (Thomas, 1902 [*Psammomys tripolitanus*]).

COMPARISONS. *Psammomys obesus* can be readily distinguished from *Psammomys vexillaris* by its darker color and greater size in all dimensions.

REMARKS. Superficially, members of this genus resemble those of the genus *Meriones* but upon closer scrutiny can be easily identified by their plain, rather than distinctly grooved, upper incisors and generally heavier, more angular skulls. Furthermore, representatives of the genus *Psammomys* are primarily diurnal, whereas jirds (*Meriones*) tend to be almost exclusively nocturnal in their habits.

Specimens of *Psammomys obesus obesus* from coastal Libya east of the Cyrenaican Plateau do not differ appreciably from those representing *Psammomys obesus obesus* from farther east in Egypt. The few specimens from the coastal plain along the Gulf of Sirte, however, differ significantly from representatives of *P. o. obesus* from Egypt and are here referred to *Psammomys obesus tripolitanus*.

ECOLOGICAL OBSERVATIONS. In Libya, these large rodents are limited in distribution to a rather narrow belt of alluvial soils and abundant vegetation, which occurs along the coastal plain and occasionally farther inland in portions of the transitional deserts. At present, specimens are not available from the coastal plain of Tripolitania, but doubtless this species occurs here also. These rodents have a similar distribution in Egypt.

All specimens I collected were from the more alluvial soils of the shoulders of the road. As presently understood, these animals are exclusively diurnal in their habits, emerging from their burrows shortly after dawn, remaining active somewhat irregularly throughout the day, and retiring to their burrows shortly after sunset. They dig large burrows with conspicuous, well-worn entrances, usually marked by piles of freshly deposited talus covered with seeds and bits of local plants. They seem to prefer the loose soils of the elevated roadbed or nearby large hillocks with a dense vegetative cover.

Frequently, during the daytime, they are seen scurrying across the road or running about the mounds while foraging. Diurnal traplines were surprisingly ineffective and only rarely were fully adult animals caught. On one occasion east of Tobruch, these diurnal traps were left in position throughout the night and produced three jirds (*Meriones*). The occurrence of these jirds in the same trapline suggests that members of these two genera occur together in the same burrow complexes. The jirds, however, forage at night and the sand rats (*Psammomys*) feed only during the hours of daylight.

Other species of rodents occurring in these more lush habitats of the Libyan coastal plain include *Gerbillus henleyi, Gerbillus campestris, Gerbillus eatoni, Jaculus orientalis, Spalax ehrenbergi,* and *Gerbillus kaiseri.*

### *Psammomys obesus obesus* Cretzschmar

*Psammomys obesus* Cretzschmar, Rüppell Atlas, 58, pl. 22, 1828 (near Alexandria, Egypt).

Specimens examined. Sixteen, from Cyrenaica: 20 km E Tobruch, 13 (1 skin only); 5 km W Bardia, 3.

Measurements. Averages and extremes of six adult females and the measurements of one adult male, 325646, from 20 kilometers east of Tobruch, are, respectively: Total length 285.8 (271–300), 288; length of tail 122.5 (110–128), 110; length of hind foot 35.2 (35–36), 38; length of ear 14.8 (14–17), 15; greatest length of skull 42.2 (40.4–43.5), 40.5; length of auditory bulla 14.3 (13.5–14.6), 13.6; alveolar length of upper molariform toothrow 7 (6.5–7.6), 6.7; least interorbital breadth 6.7 (6.3–7), 6.8; length of nasals 16.3 (15.3–17.6), 16.3; breadth of rostrum at level of antorbital foramina 4.3 (4–4.6), 4.5; greatest breadth across zygomatic arches 24.9 (23.8–25.5), 23.6; least breadth between parietal ridges 10.9 (10.5–11.2), 10.5.

Diagnosis. Pelage of dorsum dense and long but in old specimens heavily worn, particularly in middorsal region where denuded patches often disclose plumbeous-colored basal portions of hairs; sides varying from Pale Orange-Yellow to Light Orange-Yellow and flanks becoming darker in middorsal region approaching Ochraceous-Tawny; all parts of dorsum interspersed with brownish hairs; thus entire upperparts formed from a variety of colors and color patterns resulting in a pronounced variegated appearance; area between the ears and above the eyes, however, more uniformly colored Cinnamon or Ochraceous-Tawny; circumorbital areas Light Ochraceous-Buff heavily suffused with black; this color pattern extending anteriorly along the rostrum and posteriorly to the level of the ears; circumoral and mystacial areas and dorsal surfaces of fore and hind feet and legs ranging from Warm Buff to Antimony Yellow, the latter being more concentrated in the scapular regions, which appear more brightly colored than the surrounding pelage; ears relatively short, medial surface of pinna with uniform covering of buffy hairs; anterior margin of pinna with prominent row of rather stiff hairs, which project backward into inner surface of the pinna; vibrissae stiff and relatively short, formed of about equal numbers of black and buff-colored hairs; palmar surfaces of front feet naked and bearing distinct metacarpal tubercles; four primary digits (2–5) with evenly spaced transverse ridges and terminating in well-developed claws; first digit rudimentary without functional claw; plantar surfaces of hind feet with irregular

covering of hairs; all five digits well defined, sparsely haired, and all with functional claws; entire underparts strongly suffused with colors varying from Warm Buff and Ochraceous-Buff to Antimony Yellow; in all specimens an irregular whitish patch is present in the pectoral region; tail relatively short and same color as the dorsum except for some faint admixtures of brownish-colored hairs dorsally; a prominent pencil, varying in color from Cinnamon-Brown to Prout's Brown, occupying the distal one-fourth of the dorsal and ventral surfaces. Skull: Size relatively small for the genus but markedly angular and robust; zygomata extremely strong and heavy, and in older specimens, markedly bowed posteriorly; rostrum wide and heavy; anterior palatine foramina relatively short and broad; posterior palatine canals indistinct; molariform teeth heavy, grinding surfaces usually evenly worn; pterygoid processes heavy, with distinctly knobbed hamulae; auditory bulla small, not markedly inflated ventrally, but with greatly expanded meatal process, which almost touches squamous portion of temporal bone; suprameatal triangle conspicuous, usually completely enclosed by enveloping processes of temporal and supraoccipital bones; parietals with prominent lateral ridges extending from lambdoidal ridge to postorbital processes of frontal bone.

Comparisons. The specimens from near Tobruch and Bardia, Cyrenaica, differ from representatives of *Psammomys obesus nicolli* Thomas from the Nile Delta and from those of *Psammomys obesus terraesanctae* Thomas from Palestine in being markedly smaller in all measurements.

For comparisons of these specimens from Tobruch and Bardia with representatives of *P. o. tripolitanus*, see account of that subspecies.

Remarks. The specimens from Tobruch and Bardia are clearly referable to *Psammomys obesus obesus*. Except for their more brilliant yellowish-orange dorsal color and more worn-looking dorsal pelage, they are almost indistinguishable from specimens representing *P. o. obesus* from Salum, El Alamein, and other coastal localities to the east. These differences in color are well within the expected range of individual variation within a given population.

Setzer (1957) assigned specimens of *P. obesus* from El Alamein, Western Desert Governorate, Egypt, to *P. o. tripolitanus*. In a later paper, Setzer (1963) regarded these specimens from western Egypt as intergrades between *P. o. tripolitanus* and *P. o. obesus* but more closely related to the latter subspecies. The specimens from Tobruch and Bardia, Cyrenaica, in their slightly smaller size also suggest intergradation with *P. o. tripolitanus*. It is doubtful that genetic exchange is common between populations of *P. o. tripolitanus* and *P. o. obesus* because of the reduction or absence of coastal plain in many parts of northern Cyrenaica.

### *Psammomys obesus tripolitanus* Thomas

*Psammomys tripolitanus* Thomas, Proc. Zool. Soc. London, pt. 2, p. 9, 1902 (Bou Cheifa, on the coast, Cyrenaica, Libya).

Specimens examined. Six, from Cyrenaica: Gheminez, 1; 20 km SW Agedabia, 1; 10 km S Agedabia 3; 5 km W El Agheila, 1.

Measurements. Measurements of an adult female, 325630, from 20 kilometers southwest of Agedabia, are: Total length 300; length of tail 127; length of hind foot 34; length of ear 14; greatest length of skull 41.3; length of auditory bulla 14.7; alveolar length of upper molariform toothrow 7; least interorbital breadth 6.9; length of nasals 15.7; breadth of rostrum at level of antorbital foramina 4.5; greatest breadth across zygomatic arches 24.7; least breadth between parietal ridges 11.

Diagnosis. Same as for *P. o. obesus*, except dorsum with stronger suffusion of brownish hairs, and skull smaller and more gracile.

Comparisons. Compared to representatives of *P. o. obesus* from near Tobruch and Bardia, Cyrenaica, and near topotypes of *P. o. obesus* from Burg el Arab and El Daba, Western Desert Governorate, and Damanhur and Hofs, Beheira Province, Egypt, the few specimens from the coastal plain of the Gulf of Sirte are smaller in overall size of skull, have wider interorbital breadths, wider rostra, shorter anterior palatine foramina, and are darker in dorsal color.

Because the range of *P. o. obesus* is interposed between the ranges of *P. o. tripolitanus* and those of *Psammomys obesus nicolli* from the Nile Delta and *Psammomys obesus terraesanctae* from Palestine, critical comparison with the two latter subspecies was not undertaken, but from cursory examination both *P. o. nicolli* and *P. o. terraesanctae* appear to be significantly larger both cranially and in external size and dimensions. *Psammomys obesus nicolli* is also darker in color, whereas *P. o. terraesanctae* is noticeably paler and more uniformly colored than *P. o. tripolitanus*.

Remarks. Topotypes of *P. o. tripolitanus* are not available for study, but because the specimens from Gheminez and the vicinity of Agedabia agree closely with the description and measurements of *P. o. tripolitanus* as given by Thomas (1902), and because of geographic proximity, they are here referred to this subspecies.

### *Psammomys vexillaris vexillaris* Thomas

*Psammomys vexillaris* Thomas, Ann. Mag. Nat. Hist., ser. 9, vol. 16, p. 198, July 1925 (Bondjem [=Bu Ngem], Tripolitania).

General distribution of species. Libya and Algeria.

Distribution in Libya. At present, this species is known from only the vicinity of the type locality. The range probably includes most of the coastal plain and the transitional deserts of Tripolitania.

Specimens examined. One, 302254, from the Wadi Bey, 45 km W Bu Ngem, Tripolitania, Libya.

Published records. Tripolitania: Bu Ngem, Wadi Wagis (Thomas, 1902 [*Psammomys roudairei*]).

Measurements. The measurements of an old male, 302254, from near Bu Ngem, are: Total length [224]; length of tail [93]; length of hind foot 32; length of ear 12; greatest length of skull 35; alveolar length of upper molariform toothrow 6.1; least interorbital breadth 6.2; length of nasals 13.1; least breadth between parietal ridges 9.5.

Diagnosis. Upperparts varied in color owing to suffusions of various shades of buff, gray, brown, yellow and orange; a broad, indistinct Pinkish Cinnamon band extending from the rostrum to the rump; fine guard hairs projecting beyond the underlying hairs on the dorsum; sides paler in color than dorsum and with greater admixture of dark hairs; preauricular and suborbital areas grading from Light Buff to Warm Brown and strongly suffused with brownish-black hairs; circumoral and mystacial areas and region between chin and pectoral girdle white with moderate suffusion of Light Buff; postauricular patches indistinct, same color as surrounding pelage; pinnae of ears heavily furred with pale, Light Buff hairs, some of which partially cover inner aspects of pinnae. Vibrissae relatively short, formed from both black and white hairs, and extending posteriorly about 8 millimeters beyond the ears; scapular areas more brilliantly colored than surrounding areas and appearing as vaguely defined patches of Warm Buff and Light Ochraceous-Buff; this same color imparted to the pectoral region below, but more subdued here; entire underparts predominantly white, but irregularly interspersed with patches of Light Buff, Pale Ochraceous-Buff, and Warm Buff; upperparts of front legs and dorsal surfaces of forefeet Light Buff; palmar surfaces almost naked; hind feet almost pure white dorsally; sparsely haired ventrally with conspicuous naked areas on proximal one-half of plantar surfaces; forelegs with five digits with claws, the first digit being almost rudimentary; hindlegs with five functional digits bearing well-developed claws; tail relatively short, Warm Buff, and unicolorous except for a rather distinct pencil which occupies the distal one-fifth of the dorsal surface. Skull: Noticeably small and gracile; suprameatal triangles relatively large and completely enclosed by enveloping processes of the temporal and supraoccipital bones; auditory bullae large and inflated ventrally; postorbital processes and parietal crests poorly developed; anterior palatine foramina relatively long; molariform teeth large and wide; supraorbital bead absent.

Remarks. Originally, Thomas (1925) recognized two subspecies of *Psammomys vexillaris*. The range of the nominate subspecies was thought to include the coastal and interior deserts of Tripolitania,

Libya, and *Psammomys vexillaris edusa*, with type locality at Mil Mahases, Chegga, south of Biskra, Algeria, was believed to be confined to the Algerian Sahara. Ellerman and Morrison-Scott (1951) regarded *P. v. edusa* as a synonym of *Psammomys obesus vexillaris*, the species *P. vexillaris* at the same time being relegated to subspecific rank under *P. obesus*. *Psammomys vexillaris* is here accorded full specific rank, based primarily upon its smaller size, both cranially and in external dimensions, and upon additional characters as given by Thomas (1925), Setzer (1957), and the present author. Because I have examined no specimens from Algeria, I cannot comment on the status of *P. v. edusa*.

In Libya, this small sand rat is known only from the type and type series as reported by Thomas (1925) and from a single old male, 302254, obtained in 1955 by Setzer from the Wadi Bey near the type locality. According to Setzer (1957), this animal was dug from its burrow which was located in an area of consolidated sand with sparse vegetation. My efforts to obtain additional specimens of this rare sand rat were to no avail.

## Family Spalacidae

### Genus *Spalax* Güldenstaedt

#### *Spalax ehrenbergi aegyptiacus* Nehring

*Spalax aegyptiacus* Nehring, S. B. Ges. Nat. Fr., Berlin, p. 180, 1898 (Ramleh, near Alexandria, Egypt).

General distribution of species. Syria, Israel, Egypt, and Libya.

Distribution in Libya. Cyrenaican Plateau, including the Gebel Achdar and the coastal plain of Cyrenaica.

Specimens examined. Seven, from Cyrenaica: 5 km NW Labrag, 3; Wadi el Kuf, 13 km WSW Messa, 1; 8 km N Benghazi, 1; 4 km S Agedabia, 1; 20 km SW Agedabia, 1.

Published records in Libya. Cyrenaica: Ras el Ferg (Sordelli, 1899); Barce (Ghigi, 1920); Benghazi (Zavattari, 1934; Toschi, 1951).

Measurements. Measurements of two adult females, 325655 and 325656, from 5 kilometers northwest of Labrag and the measurements of an adult female, 325652, from 20 kilometers southwest of Agedabia, are, respectively: Total length 172, 180, 190; length of tail 15, 15, 16; length of hind foot 21, 22, 23; length of ear 5, 5, 5; condyloincisive length of skull 38.5, 40.7, 39.9; crown length of upper molariform toothrow 7.4, 7, 7.1; palatilar length 21.8, 22.3, 22.8; length of anterior palatine foramina 2.9, 3.2, 3.2; greatest breadth across zygomatic arches 28.8, 29.3, 29.4; least interorbital breadth 6.9, 6.4, 6.7; length of nasals 16.6, 17.8, 17.8; breadth of rostrum at level of antorbital foramina 7.1, 6.9, 7.4; greatest length of skull

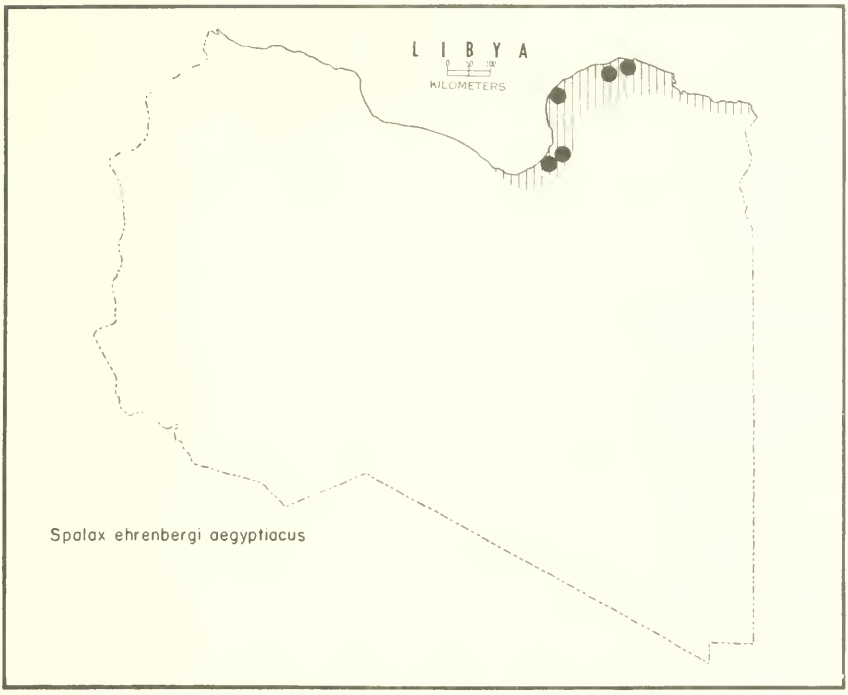


FIGURE 42.—Distribution of *Spalax ehrenbergi aegyptiacus*.

41.2, 43.6, 42.8; length of diastema 14.2, 14.7, 15; basilar length of skull 34, 35.7, 35.2; greatest breadth of rostrum 7.5, 8, 8.1.

DIAGNOSIS. Most distinctive feature is the featureless, cylindrical body without a visible tail, and superficially appearing to lack eyes, ears and nostrils; rostrum furnished with a hardened and slightly enlarged cartilaginous plate beneath the skin and near the origin of the vibrissae, which presumably aids in pushing and moving dirt in the underground tunnels; vibrissae correspondingly small and fine in texture; pelage short, dense, and silky and of almost uniform color dorsally, varying in different specimens, however, among shades of Ochraceous-Tawny, Sayal Brown, and Buckthorn Brown, and ventrally somewhat darker owing to less suffusion of these colors. In older specimens, pelage becoming worn and somewhat darker owing to greater exposure of the Plumbeous underfur; rostrum, in young specimens, light gray in color, but, in old specimens, rostral, auricular, and entire facial areas becoming a much darker gray; eyes not visible externally, but present as small rudimentary structures in the usual position in the orbit; pinnae of the ears, on close examination, present as inconspicuous cartilaginous rings which are obscured by the dense

pelage; forefeet, bearing five digits with claws, remarkably small in view of the fossorial habits of these rodents; hind feet also relatively small and with five digits, but with larger claws; fore and hind feet approaching color of dorsum, but naked ventrally. Skull: Large, massive, and angular with conspicuous development of the lambdoidal and sagittal crests; shape of skull almost triangular in outline owing to the relatively small braincase, the abrupt anterior convergence of the zygomata and the relatively short and wide rostum; interorbital breadth markedly constricted; supraoccipital markedly expanded dorsally, with numerous inflated elevations, and directed a considerable distance anteriorly; incisors extremely long, relatively narrow, and orange in color on their anterior faces; molariform teeth moderate in size with intricate interwoven patterns in the enamel and dentine, and with conspicuous styles on the lateral surfaces; infraorbital foramina large with corresponding reduction in size of the frontal plate of the premaxillae; dorsal margin of foramen magnum smoothly rounded; auditory bullae markedly reduced to thick, heavily ossified structures with prominent external meatal processes and conspicuous, attenuated styliform processes; anterior palatine foramina markedly reduced in size; palate with prominent midventral rib; posterior palatine canals small and inconspicuous; pterygoid processes heavy and with club-shaped hamulae; basioccipital broadly wedge-shaped.

Remarks. Nehring (1897) regarded the mole rats of the Near East as representing several distinct species. He described *Spalax ehrenbergi* from Jaffa, Palestine, *Spalax kirgisorum* Nehring from northern Syria, *Spalax intermedius* Nehring from farther south in Syria, and named *Spalax aegyptiacus* Nehring with the type locality at Ramleh, near Alexandria, Egypt. Later, Mehely (1913) regarded all members of this group as one species and considered *S. kirgisorum* and *S. aegyptiacus* as varieties of *Spalax ehrenbergi*. Many years later, Ellerman (1941) elevated *S. kirgisorum* to full species status on the basis of page priority in the original description and relegated *S. ehrenbergi* and *S. aegyptiacus* to subspecific rank, thus reversing the taxonomic status of *S. ehrenbergi* and *S. kirgisorum*. A short time later, Bate (1945) observed that, although the description of *S. kirgisorum* clearly preceded that of *S. ehrenbergi*, the latter form is given a prior place in illustrations of cheek teeth, and is followed by *S. kirgisorum*. She stated that in works published prior to 1931, figures are acceptable as valid descriptions, and therefore the name *Spalax ehrenbergi* should be regarded as antedating that of *Spalax kirgisorum*.

More recently, Ellerman and Morrison-Scott (1951) consider *S. ehrenbergi* as a valid species but regard *S. kirgisorum* as a synonym of *S. ehrenbergi ehrenbergi*. Thus, the species *S. ehrenbergi* is currently composed of two subspecies, *S. e. ehrenbergi* and *S. e. aegyptiacus*.

Toschi (1954) assigned specimens from Ras el Ferg, Barce and Benghazi, Cyrenaica Province, Libya, to *S. e. aegyptiacus*. Although Setzer (1957) saw evidences of mole rats at Gheminez, Derna, Barce, and near Agedabia, he obtained no specimens.

In the present study, I obtained seven specimens from four localities in Cyrenaica. Although they are from widely separated localities which differ rather sharply in characteristics of soil, vegetative cover, and climate, they are quite similar morphologically. They differ noticeably, however, from representatives of *S. e. aegyptiacus* from Burg el Arab, Western Desert Governorate, Egypt, in their smaller size of most external and cranial measurements, narrower rostra, which are more constricted at the level of the infraorbital foramina, more delicate zygomata, broader frontal plates of the premaxillae, larger infraorbital foramina, smaller, narrower, and shorter incisors, and more smoothly rounded dorsal margin of the foramen magnum. In the specimens from Cyrenaica, the styliform process of the auditory bulla is more attenuated and projects farther medially, and the angular process of the mandible is smaller and more knobbed.

The above differences would normally be sufficient to warrant considering these Libyan mole rats as belonging to a distinct subspecies, but too few specimens are available for accurate designation. Furthermore, they agree rather closely with the cranial measurements given for *Spalax aegyptiacus* in the original description.

Despite the foregoing differences, I consider it best, until such time as additional specimens of mole rats are forthcoming, to refer all Libyan specimens to *S. e. aegyptiacus*.

Ecological observations. Mole rats are common on the coastal plain and uplands of the Cyrenaican Plateau and are relatively common farther south and west along the coastal plain of the eastern portion of the Gulf of Sirte. On the Cyrenaican Plateau and the Gebel Achdar, they seem to prefer loose soils at the margins and bottoms of the larger valleys and the more fertile soils of the higher tablelands. Mounds were also observed on the rocky slopes north of El Faidia near the highest point of the Cyrenaican Plateau.

These rodents apparently attain the southwesternmost limits of distribution for the species on the coastal plain south and west of Agedabia. Currently they are unknown from the Tripolitanian coastal plain. Mole rats occur inland for varying distances, probably depending upon the amount of rainfall for a particular year. While en route to Gialo in the spring of 1962, we saw fresh diggings 25 kilometers inland from the Mediterranean coast. Setzer (in verbis) also attests to their presence in these inland localities. It is almost certain that they do not occur in or near the oases of the Saharan interior.

These remarkable rodents plug the entrances to their burrows with soil, and they are rarely observed above ground. On several occasions, movements of the plug or fresh talus were observed during the daytime, indicating that they are active both day and night. Specimens were obtained with the use of Macabee gopher traps but only after exhaustive efforts because of the unusually hard, resistant nature of the soil. The small diameter of the entrance of the burrow, which was almost always difficult to locate, and the insistence of these mole rats on pushing fresh dirt over the trap, made trapping difficult.

During the rainy season in the spring, the soils of the coastal plain are relatively soft and easily workable, and diggings of mole rats are widespread. Accordingly, traps can be more easily set, and the yield is greater. Later in the summer, after the soil has hardened, the number of active burrows is greatly reduced, and in some localities collecting mole rats is much more difficult, if not impossible. At this time these soils of the coastal plain become almost impervious.

It is interesting to note that mole rats occupying the more firmly packed soils of the Cyrenaican Plateau are generally smaller than those living in the softer, more sandy soils of the coastal plain. Selection has apparently favored smaller body size in these areas where digging is more difficult and a smaller diameter of the burrows is desirable. The soils of the Cyrenaican Plateau are probably harder and less sandy than those of the Egyptian littoral farther east, and this differential in hardness of the soil may account for the differences in size of mole rats from the two areas.

The character of the soil seems to be the most critical factor in the distribution of these burrowing rodents, and vegetative cover and other physical features of the terrain are of secondary importance. One specimen, 325652, from near Agedabia was taken from a series of active burrows in the extremely hard-packed soil near the roadside on a grassy portion of the coastal plain. These grassy areas, most of which contained diggings, were interspersed among the rather dense, shrubby vegetative cover of the coastal plain. Another specimen, 325651, was obtained farther inland where the coastal plain is broad and featureless and has a more uniform vegetative cover. This specimen was obtained during the spring when the recently emerged grasses were lush and green, and the soil, which normally would have been almost impervious, was soft and workable. Near Labrag, three specimens were obtained from the high uplands of the escarpment which forms the northern terminus of the Cyrenaican Plateau. Even though fresh diggings were widespread, the soil here was extremely hard and rocky, and the specimens were obtained only after laborious efforts. A single specimen, 325657, was obtained from the more alluvial soils in the bottom of the Wadi el Kuf where the ground was also nearly impervious.

According to Setzer (1957) and Hartert (1923), the local Arabs believe that because mole rats lack visible eyes and are apparently blind, anyone having contact with them will also become blind.

## Family Muridae

### Genus *Rattus* Fischer

#### *Rattus norvegicus* (Berkenhout)

*Mus norvegicus* Berkenhout, Outlines N. H. Great Britain and Ireland, vol. 1, p. 5 (Great Britain).

Remarks. In Libya, the Norway rat is known only from Tripoli (Toschi, 1951), although it probably occurs in most, if not all, of the larger coastal cities and may occur in the wild state in the Cyrenaican Plateau.

They are thought to be endemic to northern China and Manchuria. In recent centuries, they have been carried westward as a result of the increased development of western commerce. Their introduction into North Africa most likely was through the agency of shipborne rats in the major ports where ships frequently unloaded their produce.

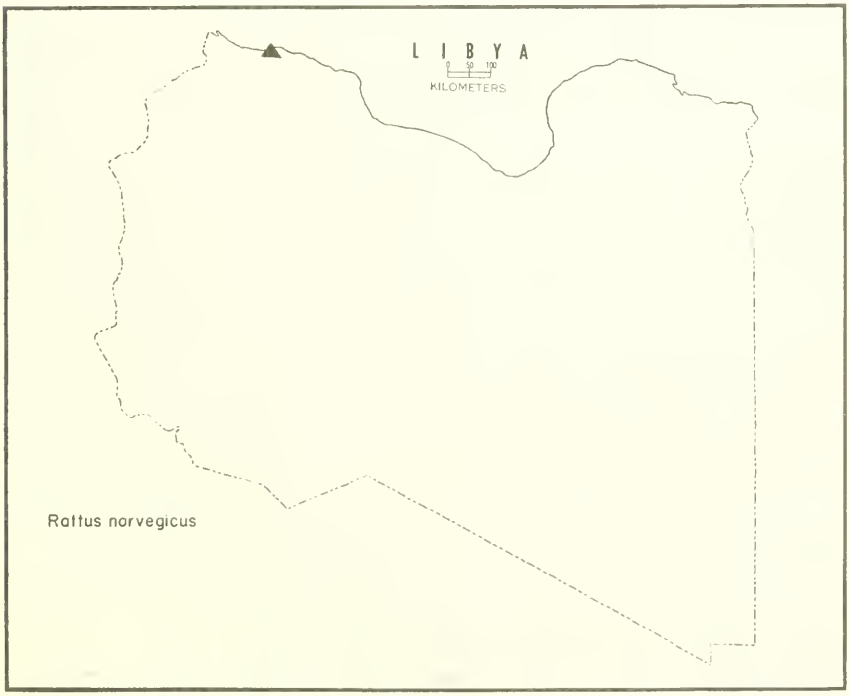


Figure 43.—Known locality of occurrence of *Rattus norvegicus*.

According to Rode (1948), the Norway rat is abundant in all ports of North Africa and occurs also in the large villages of the interior. It is doubtful that they occur in the Saharan interior of Libya. These rats are known to have a definite predilection for moist habitats and frequently inhabit stream banks where they demonstrate marked abilities for swimming and burrowing. Even in the tropics, they survive only where the habitat has been significantly altered by man. Moist habitats in some of the larger oases of Cyrenaica and the Fezzan may provide the ecological requirements of these rats, but these areas are sporadic and localized. In addition, the barriers imposed by vast areas of desolate sand and arid desert must be surmounted before they could become established in these interior oases.

In the present study, I collected extensively for several months in the interior oases and made frequent inquiries regarding the local rodent fauna. During this period I was unsuccessful in obtaining any rats (*R. rattus* or *R. norvegicus*) and observed no indications of their presence.

### *Rattus rattus* (Linnaeus)

*Mus rattus* Linnaeus, Syst. Nat., 10th ed., vol. 1, p. 61 (Sweden).

General distribution of species. Nearly cosmopolitan owing to its commensal relationship with man; it is said to occur in the wild state in most of India, West Pakistan, Ceylon, foothills of the Himalayan Mountains, Southern China, Burma, Thailand, Laos, Viet Nam, Malaya, and in the larger islands of the southwestern Pacific, including the Philippine Islands.

Distribution in Libya. Occurs commensally with man in the larger coastal cities of Benghazi, Tripoli, and Derna and apparently is present in the wild state in parts of coastal northern Cyrenaica.

Specimens examined. Four, from Cyrenaica: 27 km E Apollonia, 3; 12 km NW Gubba, 1.

Published records in Libya. Cyrenaica: Benghazi (Festa, 1925 [*Epimys tectorum* Savi]); Derna, Merg (=Barce) (de Beaux, 1938 [*Rattus rattus nericola* Cabrera]); Tripolitania: Tripoli (Toschi, 1951 [*Rattus rattus frugivorus* Rafinesque]).

Measurements. Measurements of an adult female, 325658, from 27 kilometers east of Apollonia, are: Total length 343; length of tail 192; length of hind foot 33; length of ear 24; greatest length of skull 39.7; condylobasal length of skull 38.2; alveolar length of upper molariform toothrow 6.9; greatest breadth across zygomatic arches 19; least interorbital breadth 5.5; length of nasals 14.5; length of audital portion of auditory bulla 7; palatal length 21.7; breadth of rostrum at level of antorbital foramina 4; length of anterior palatine foramina 7.

Diagnosis. Upperparts varying among shades of Prout's Brown, Snuff Brown and Sepia; a large portion of the hairs of the shoulders,

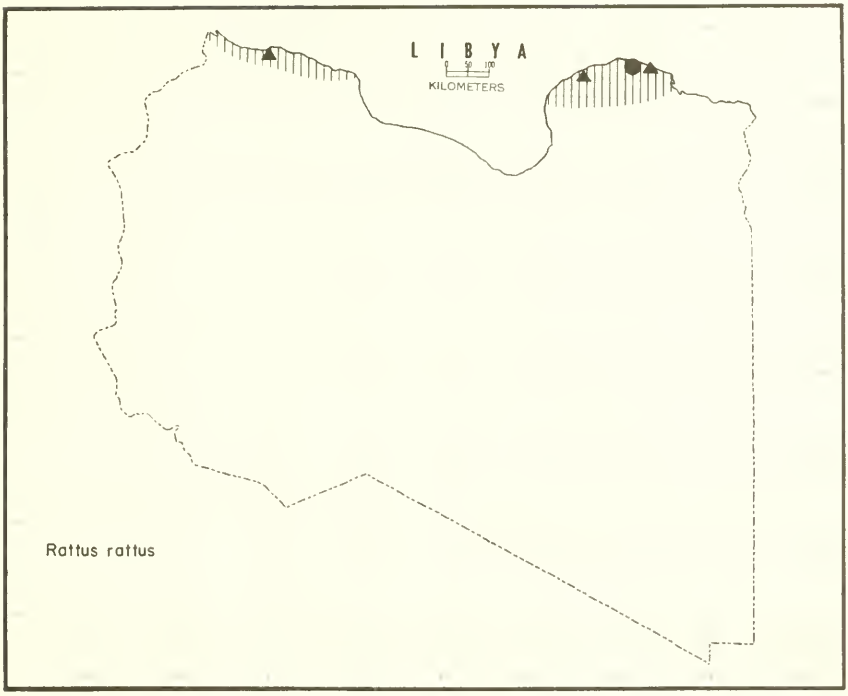


FIGURE 44.—Distribution of *Rattus rattus*. Circle indicates specimens examined; triangles indicate published records.

scapular areas, and back tipped with Cinnamon-Buff and appearing more lustrous than surrounding pelage; pale underparts contrasting markedly in color with that of the dorsum and varying from almost pure white in the region of the chin to Marguerite Yellow and Primrose Yellow in the midventral region, and becoming Light Buff laterally; vibrissae relatively long and formed entirely of black hairs; ears large, naked, thin, paper-like in texture and Olive-Brown in color; front feet relatively small, buff-colored above, naked below, and bearing four functional digits with short claws; hind feet proportionately larger than forefeet and with five functional digits rather than four, Light Buff above and naked below with a richly pigmented plantar surface bearing numerous prominent tubercles; tail long and attenuated, appreciably longer than the head and body, and covered throughout its entire length with short, stiff, inconspicuous hairs which arise from between annular segments. Skull: Medium in size; gracile and narrow in outline; zygomata relatively delicate and bowing slightly laterad; braincase relatively flattened; auditory bullae small and moderately inflated ventrally; anterior palatine foramina long and wide; temporal ridges lyre-shaped; basioccipital broadly wedge-shaped.

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Comparisons. *Rattus rattus* can be distinguished from *Rattus norvegicus* by the following characters: Longer and more uniformly colored tail; one pair of postaxillary, pectoral mammae, rather than two pairs; smaller front feet; lyre-shaped temporal ridges, as opposed to parallel temporal ridges; first molar lacking the small accessory cusp, the latter being present in *R. norvegicus*.

Remarks. Earlier workers in the systematics of rodents have applied subspecific names to the three common color types of the commensal or black rat (*Rattus rattus*). These color types are characterized as: black or gray above and below; brown above and dark gray below; brown above and white below; and correspond, respectively, to the subspecies *R. r. rattus* (Linnaeus), *R. r. alexandrinus* (Geoffroy), and *R. r. frugivorus* (Rafinesque). In the past, the commensal rats of the larger coastal towns of Libya have been variously assigned to one or more of these subspecies. More recently, ecological, behavioral, and genetic studies indicate that these so-called subspecies do not conform to the modern concept of subspecies and accordingly should be regarded only as color phases or genetic variants within the species.

Caslick (1955), in an attempt to resolve some of the relationships of these color types in *Rattus rattus*, conducted a series of selective matings of wild-trapped black rats of mixed origin, and although, in color, the litter mates satisfied the requirements of subspecies and "unclassifiable intergrades" were of rare occurrence, he concluded that the current forms of *R. rattus* were best regarded as color phases within the species.

Setzer (1952) also recognized these same three color types in commensal rats from the Nile Delta and noted that specimens from a given locality segregated out as the three expected color types plus intermediate forms. These intermediate forms, to which he attributed a single gene character for melanism, were suggestive of intergrades, but the presence of three distinct subspecies occupying the same environmental niche (or geographic area) was clearly untenable. Other workers have frequently reported black rats of different color phases sharing the same habitat, and the individuals in a given population that did not conform to one of the so-called subspecies were considered intergrades.

Johnson (1946) commented on a litter from the same nest that contained representatives of both the white-bellied and black-bellied color phases and stated that these color phases had no morphological distinctions, except those of color, and that the ecological differences mentioned by other workers were not evident in the population that he studied.

Caslick (1955) suggests that the color phases of the commensal rat, recognized as the subspecies *R. r. rattus*, *R. r. alexandrinus*, and *R. r.*

*frugivorus*, may be similar to the well-known color phases of the black bear, red fox, and the gray and fox squirrels.

No differences have been observed in the habits, movements, and survival differential of *R. r. rattus* and *R. r. alexandrinus*, although *R. r. frugivorus* has been considered by some to represent a "wild form" which frequently occurs in the feral state in fields and agricultural areas. In many cities and villages of Europe, North America, and North Africa, all three of these color types occur together.

In my opinion, the recognition of *rattus*, *alexandrinus*, and *frugivorus* as subspecies of *R. rattus* is of doubtful utility, and I prefer to regard these so-called subspecies as merely color phases or phenotypic variants within this widely ranging species.

If one subscribes to the older system of applying subspecific names to the commensal rats of Europe and North Africa, the four specimens from Cyrenaica clearly represent *R. r. frugivorus*.

The four specimens from Cyrenaica were trapped in the lush vegetation bordering small permanent streams. The collecting site near Gubba is located in a deep canyon of the coastal escarpment and several kilometers from the nearest human habitation, whereas the specimens from near Apollonia were taken from an elevated portion of the coastal plain in traps set only a few hundred meters distant from human dwellings. These specimens from Cyrenaica constitute the first records of *R. rattus* occurring in the wild state in Libya. They are unknown from the oases of the interior.

## Genus *Mus* Linnaeus

### *Mus musculus* Linnaeus

*Mus musculus* Linnaeus, Syst. Nat., 10th ed., vol. 1, p. 62, 1758 (Upsala, Sweden).

General distribution of species. Cosmopolitan as a result of introduction by man.

Distribution in Libya. Occurs as a commensal with man in the larger coastal cities and villages of the interior and is quite widely distributed in the wild state.

Specimens examined. One hundred fifty-eight, from Cyrenaica: 27 km E Apollonia, 11; 11 km SW Susa (=Apollonia), 3; 5 km NW Labrag, 6; 12 km NW Gubba, 2; Cyrene, 1; 3 km E Derna, 2; 35 km W Messa, 1; 10 km SW El Faidia, 3; 7 km E Maraua, 1; 5 km W Tocra, 49 (1 skin only); 20 km SW Tocra, 3; Giarabub, 2; El Hauuari, Cufra Oasis, 1; El Giof, Cufra Oasis, 12; from Tripolitania: 5 km W Cussabat, 3; 12 km S Chicla, 2; 7 km S El Gheddahia, 1; 20 km E Sirte, 1 (skin only); from Fezzan: Brach, 37 (10 skull only); Sebha, 1; Goddua, 11 (7 skull only, 2 skin only); Meseguin, 2; Traghen, 1; 28 km E Murzuch, 1; Murzuch, 1.

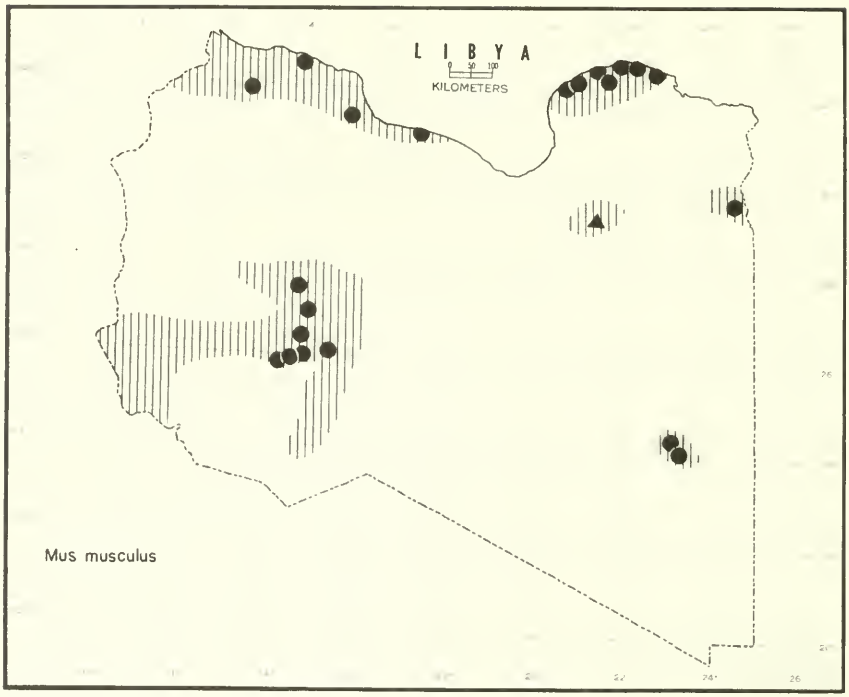


FIGURE 45.—Distribution of *Mus musculus*. Circles indicate specimens examined; triangle indicates published record.

PUBLISHED RECORDS IN LIBYA. CYRENAICA: Benghazi, Derna (Klaptocz, 1909 [*Mus musculus orientalis* Cretzschmar]); Benghazi, Gheminez (Festa, 1921 [*Mus musculus gentilis* Brants]); Benghazi (Hartert, 1923); Giarabub (de Beaux, 1928 [*Mus musculus musculus* and *M. m. orientalis*]); Augila, Cufra and Gialo (de Beaux, 1932 [*M. m. orientalis*]); Derna, Wadi el Kuf (*M. m. orientalis*) and Merg (*Mus musculus brevirostris*) (de Beaux, 1938); TRIPOLITANIA: Tarhuna (Thomas, 1902 [*M. m. orientalis*]); Tripoli (Klaptocz, 1909 [*M. m. orientalis*]); FEZZAN: Idri, Murzuch (Toschi, 1951 [*M. m. gentilis*]).

MEASUREMENTS. Averages and extremes of 17 males and 8 females from Brach, Fezzan Province, are, respectively: Total length 164.1 (149–182), 158.6 (156–163); length of tail 82.9 (76–90), 78.3 (75–81); length of hind foot 19 (18–20), 18.8 (18–19); length of ear 16.6 (14–21), 15.4 (14–20); greatest length of skull 22 (20.7–23.2), 21.3 (20.7–22.2); condyloincisive length of skull 21.1 (19.6–22.2), 20.4 (19.8–21.3); crown length of upper molariform toothrow 3.7 (3.3–4), 3.7 (3.6–3.9); greatest breadth across zygomatic arches 11.5 (10.9–11.9), 11.3 (10.9–11.6); least interorbital breadth 3.6 (3.5–3.8), 3.7 (3.5–3.8); length of nasals 8.2 (7.5–8.6), 7.8 (7.1–8.4).

Diagnosis. Two distinct color types of *Mus musculus* occur in Libya, a light-bellied form and a dark-bellied form. In the light-bellied form, the hairs of the venter are either white throughout or white distally with plumbeous bases. The dark-bellied form has gray or brown-tipped hairs on the venter, which are always plumbeous basally. The color of the dorsal and ventral pelage is markedly contrasting in the white-bellied form, whereas, in the dark-bellied form, the color of both surfaces is quite similar. The two forms differ appreciably in the color of the dorsum, that of the dark-bellied form being markedly and more uniformly darker (ranging from Saccardo's Umber to Sepia); in the light-bellied form, it is more variable and ranges from Clay Color to Olive Brown and frequently is variegated owing to suffusions of gray and buff. The dorsal surfaces of the hind feet are dusky or gray in the dark-bellied form, whereas they are almost white in the light-bellied form. In both forms, the tails are naked except for a scanty covering of inconspicouus whitish hairs.

Cranially, the two types do not differ significantly and both have extremely small, gracile skulls with flattened braincases, short rostra (more pronounced in the white-bellied form), large anterior palatine foramina, small posterior palatine canals, relatively small cheek teeth, broad basioccipitals, and small, bulbous auditory bullae. The "*Mus* notch" is pronounced on the upper incisors.

Remarks. The systematic status of the house mouse (*Mus musculus*) has never been firmly established. The principal effort to resolve the nomenclatural relationships of *Mus musculus* is that of Schwarz and Schwarz (1943), who considered the wild species, *Mus musculus*, to originally consist of four subspecies, *M. m. wagneri* Eversmann, *M. m. spicilegus* Petényi, *M. m. manchu* Thomas, and *M. m. spretus* Lataste. According to the above authors, these wild forms (except for *M. m. spretus*, which occurs exclusively in the wild state) have given rise to the various commensal forms of the house mouse throughout the world. Schwarz and Schwarz contend that most of these commensal forms, except those of western Europe, Russia, and Japan, have been derived from *M. m. wagneri*, which developed both an eastern and western series of commensals. The commensal *Mus musculus* of Libya supposedly arose from the western component of *M. m. wagneri*, which had its origin in southwestern Persia (=Iran) and from which it spread, by the agency of man and cultivation, through Iraq, Turkey, Syria, Israel, the Nile Valley, and westward across North Africa. From Africa these commensal forms have reached Italy, Spain, and western Europe.

Throughout most of their range, depending upon the degree of specialization, these commensals form two types, a more specialized "commensal" from and a more generalized "wild" form. The com-

mensal form, according to Schwarz and Schwarz, has evolved along specific lines in response to its more intimate association with man and normally has a longer tail (frequently longer than the length of the head and body), a darker (more grayish) venter, richer (darker) shades of color dorsally, a shorter face, and smaller molariform teeth. In the wild form, the tail is shorter (always shorter than the length of the head and body), the venter is white, rather than gray, and forms a sharper contrast with the color of the pelage of the sides and flanks. These authors contend that, in many areas, both indoor and outdoor types of house mice are found. The outdoor (feral) types may represent either wild or commensal types, which are less specialized than the indoor types.

The house mice of Libya, according to Schwarz and Schwarz, are represented by two subspecies, *M. m. praetextus* Brants and *M. m. brevirostris* Waterhouse, representing, respectively, the wild and commensal forms.

Toschi (1954, pp. 264–265) summarized the work of all previous workers on Libyan mammals and listed four subspecies of *Mus musculus* as occurring in Libya. These included *M. m. musculus*, *M. m. brevirostris*, *M. m. gentilis* (=*M. m. praetextus*), and *M. m. orientalis*. Both *M. m. gentilis* and *M. m. musculus* were listed from Benghazi and apparently represented, respectively, the feral and commensal forms of *M. musculus*. These subspecies mentioned by Toschi were based on specimens from widley scattered localities in Libya, and many were assigned to a given subspecies without regard to distributional or taxonomic concepts.

In the present study, many more specimens are available from widely scattered localities in Libya, and two distinct color types are discernible. Those from all interior localities represent the light-bellied form and are white ventrally with the individual hairs white throughout or plumbeous-colored basally. Dorsally, the coloration varies from extremely pale individuals to quite dark-colored forms. In all specimens from the interior of Libya, the dorsum and venter are markedly contrasted in color. Specimens from the coastal plain near Tocra in Cyrenaica typify the dark-bellied form in which the venter is gray or brown and thus not contrasting with the color of the dorsum. Light-bellied individuals also occur near Tocra but are less abundant.

Setzer (1957) obtained both feral and commensal house mice in Libya and was able easily to distinguish two types on the basis of their dorsal and ventral coloration. He found, based on color, that the commensal kind agreed with the description of the feral form given by Schwarz and Schwarz, and that the feral kind agreed with the description of the commensal form as given by the above authors. He further stated that these color types did not represent subspecies as understood by modern taxonomists.

All Libyan specimens I collected were taken in the wild or feral state and, except for those from the Cyrenaican coastal plain, conform in the pattern of their coloration to the wild form *M. m. praetextus* as established by Schwarz and Schwarz. The dark-bellied specimens from the coastal plain clearly represent the commensal form, *M. m. brevirostris*. These coastal specimens have shorter rostra than those from other localities, which is a character used by Schwarz and Schwarz to separate *M. m. brevirostris* from *M. m. praetextus*, but they lack the long tail which is reputed to be a character of the commensal form. Furthermore, both color types occur together on the coastal plain near Tocra, and neither show commensal tendencies. To me, these different color types are only color variants of the same subspecies. On the coastal plain near Tocra, and doubtless in many other localities in Libya, both color types (or subspecies) occur together; this clearly violates the concept that "no two subspecies occupy the same geographic range." For these reasons, I prefer to assign all of these mice occurring in Libya to the species *Mus musculus* and suggest that the different color types be interpreted as various stages in commensalism rather than as distinct subspecies as used in the context of modern taxonomists.

Ecological observations. In Libya, house mice are widely distributed and occur in a wide variety of habitats. Frequently, they act as strict commensals sharing the same dwellings as the local people. At some localities, they inhabit gardens and palm groves of the larger villages and oases. In many areas, they exist in the wild or feral state, completely divorced from the nearest influence of man.

The largest series were taken on the coastal plain or from the larger interior oases. At Brach, in the Fezzan, house mice are abundant in the interior of the oasis where slightly elevated patches of *Phragmites* are interspersed among areas of open water. They are common inhabitants of the dense pockets of sedges and other mesophytic plants that encircle the saline lakes at El Giof and El Hauuari at Cufra Oasis. On the coastal plain near Tocra, Cyrenaica, a large series was taken from the dense, brush-covered coastal plain near the sea. In other parts of Cyrenaica, they occur in the dense, mesophytic plant cover bordering small permanent streams or inhabit localized mesic pockets in the coastal escarpment. They were occasionally trapped in the chaparral vegetation of the higher portions of the Cyrenaican Plateau.

Relatively high humidity, mesic conditions, and dense plant cover are the features common to all the above habitats. Only rarely are these commensal mice taken from dry situations, and they never inhabit soils formed exclusively of sand. Perhaps these dry habitats are marginal and the collection of house mice from them was entirely fortuitous.

It is interesting to note that apparently house mice are absent from several of the large oases of southern Cyrenaica, such as Tazerbo and Bzema. Suitable habitat occurs in these isolated oases, but, unlike Cufra Oasis, they are far removed from the caravan routes and have relatively few outside visitors; thus, the introduction of commensals has probably never taken place.

## Genus *Acomys* Geoffroy

### *Acomys cahirinus viator* Thomas

*Acomys viator* Thomas, Proc. Zool. Soc. London, pt. 2, p. 10, 1902 (Wadi Sultan, near Socna, Tripolitania, Libya).

General distribution of species. Libya, Egypt, and Algeria, and range probably includes additional countries and provinces of the Sahara.

Distribution in Libya. This species is known from only the type locality near Socna, Tripolitania Province, and from the oases of El Barcat, Fezzan Province, and El Giof (Cufra Oasis), Cyrenaica Province.

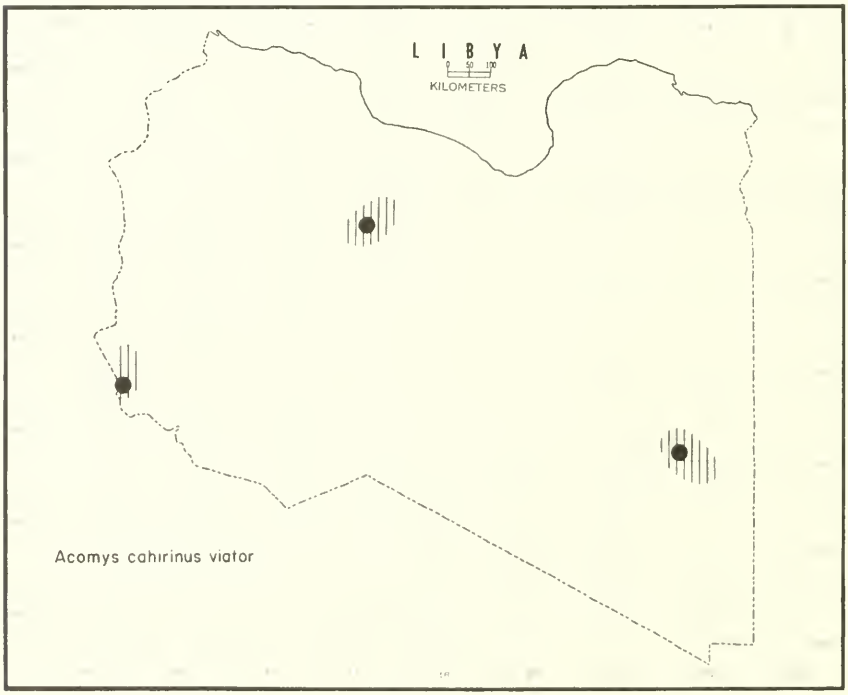


Figure 46.—Distribution of *Acomys cahirinus viator*.

Specimens examined. Twenty-three, from Cyrenaica: El Giof, Cufra Oasis, 19; from Tripolitania: 5 km S Socna, 1; Bir Fergian, 10 km S Socna, 1 (skin only); from Fezzan: El Barcat, 2.

Measurements. Averages and extremes of 7 adult males and 10 adult females from El Giof, Cufra Oasis, are, respectively: Total length 202 (195–209), 203.1 (185–229); length of tail 104.3 (100–107), 104.3 (99–115); length of hind foot 19.4 (19–20), 19.4 (19–20); length of ear 19.6 (19–20), 19 (19–19); greatest length of skull 29.3 (28.4–30.1), 28.7 (27.3–30); condyloincisive length of skull 27.3 (26.7–28), 26.5 (25–27.6); crown length of upper molariform toothrow 4.2 (4.1–4.3), 4.2 (4–4.5); breadth of rostrum at level of antorbital foramina 3.2 (3.1–3.3), 3.2 (3.1–3.3); least interorbital breadth 4.8 (4.7–5), 4.8 (4.6–5); greatest breadth across zygomatic arches 14.4 (14–14.9), 14 (13.3–14.7); median length of nasals 10.5 (10.1–10.8), 10.3 (9.7–10.6).

Diagnosis. Upperparts ranging from Smoke Gray on scapular areas and sides to Deep Grayish Olive on middorsal region and rump; pelage of rump coarse and hispid owing to individual hairs modified into stiff bristles and spines; total dorsum mildly suffused with tones of Light Drab; base of pinna surrounded by band of distinct buffy-gray hairs; pinna large, sparsely haired, and ranging in color from Deep Grayish Olive to Dark Grayish Olive; chin, mystacial, and circumoral areas, forelegs, hindlegs, dorsal surfaces of fore and hind feet, and entire underparts pure white; ventral surfaces of fore and hind feet naked, with distinct palmar and plantar pads, and bearing five digits with claws; vibrissae relatively long, fine in texture, and formed largely of grayish hairs; tail fusiform, conspicuously bicolored, Clove Brown above and Deep Olive-Buff below, and composed throughout its entire length of successive, imbricated segments, from the bases of which arise short, stiff, white hairs. *Skull:* Medium in size; parietals slightly expanded dorsally; anterior palatine foramina long and wide; molariform teeth relatively small and toothrow short; pterygoid fossae broad and long and with prominent elliptical foramina on laterocaudal margins; auditory bullae small and noticeably inflated ventrally; pterygoid processes convergent anteriorly and forming a distinct rib separating the halves of the pterygoid fossae and extending to the level of the palate.

Comparisons. From specimens representing *Acomys cahirinus cahirinus* (Geoffroy) from various localities both east and west of the Nile River, Egypt, specimens from El Giof, Cufra Oasis, differ in slightly more robust skulls, particularly the rostrum and zygomata, slightly wider braincases, more expanded parietals, and a larger foramen on the laterocaudal portion of the pterygoid fossa. The foramen magnum, in specimens from El Giof, is more rounded dorsally and

extends farther dorsally into the supraoccipital bone. In external measurements the populations from Egypt and Libya are comparable, but, in color, the Libyan specimens are more uniform, whereas the Egyptian specimens show a wide range of color, divisible generally into two distinct color phases.

The Libyan specimens differ significantly from representatives of *Acomys dimidiatus dimidiatus* (Cretzschmar) form Feiran Oasis, Sinai, in their smaller, more gracile skulls, more flattened braincases, and narrower anterior palatine foramina. The foramen magnum, in the Libyan specimens, is much more rounded dorsally and the foramina in the pterygoid fossae are appreciably larger. In color, they are much darker, gray as opposed to buff, and more uniformly colored.

In cranial measurements, specimens from Cufra resemble those of *Acomys dimidiatus hunteri* de Winton from the Eastern Desert Governorate of Egypt and the Sudan, but differ markedly from the latter in their darker color, smaller size, prominently rounded dorsal surface of foramen magnum (as opposed to markedly flattened or truncated in *A. c. hunteri*), and shorter anterior palatine foramina.

Remarks. The series of spiny mice from Cufra Oasis is here referred to *Acomys cahirinus viator* but with reservations. In color, specimens from Cufra closely resemble two near topotypes of *A. c. viator* from near Socna and Bir Fergian, Tripolitania. They are slightly smaller in overall length but are of comparable size in all other external dimensions. Unfortunately, the skull of the adult specimen from Bir Fergian was lost, and the other specimen from near Socna is extremely young; thus, cranial comparisons are not possible. Compared to measurements of the type specimen of *A. c. viator*, as given by Thomas (1902) in the original description, specimens from Cufra are slightly smaller in greatest length of skull and have slightly wider interorbital breadths.

It seems unlikely that the same subspecies would occur in such widely separated geographic areas in Libya, such as Socna, El Barcat, and Cufra, particularly since suitable habitat is sporadic and localized. The referral of these specimens to *A. c. viator* must therefore be considered provisional until such time as additional specimens of *A. c. viator* are forthcoming and permit more accurate comparisons. Spiny mice from Cufra represent geographic isolates, clearly distinct morphologically from all other populations to the east, and probably will prove also to be subspecifically distinct from *A. c. viator*.

In the past, *A. cahirinus* and *A. dimidiatus* have been variously regarded as either distinct species or the latter treated as a subspecies of *A. cahirinus*. Ellerman and Morrison-Scott (1951) regarded the smaller *A. cahirinus* purely as a commensal form and relegated the larger and exclusively wild form (*A. dimidiatus*) to subspecific status under *A. cahirinus*. Setzer (1959) recognized two species of spiny mice as occurring in Egypt and Sinai; he considered *A. cahirinus*

as a strict commensal but regarded it as a monotypic species with a range confined to the Nile Valley and distinguishable from *A. dimidiatus* by more flattened braincase, more rounded foramen magnum, more nearly vertical (less recurved) upper incisors, and broader and less elongated pterygoid fossae.

The above differences are apparent when spiny mice from Sinai and Baluchistan, Iran, are compared to those from the Nile Delta, but specimens from Libya do not show these same differences, and there is too much overlap of characters among populations of these mice from Libya and the Nile Valley to suggest specific differences. I agree with Setzer that the "*cahirinus* group" is divisible into two species, *A. cahirinus* and *A. dimidiatus*, but extend the range of *A. cahirinus* to include Libya, as well as the Nile Valley of Egypt, and limit the range of *A. dimidiatus* to areas to the south, east, and north. For the present, until a thorough revisionary work of this poorly understood genus has been undertaken, I prefer to include the spiny mice of Libya and the commensal forms of the Nile Valley of Egypt within a single species, *Acomys cahirinus*. Commensalism is unknown in the Libyan populations, but this is not a valid criterion for specific designation and could have arisen independently in the populations of spiny mice in the Nile Valley.

Cranially, two specimens from El Barcat in the extreme southwestern Fezzan resemble those from Cufra but differ in having more flattened and wider braincases, shorter anterior palatine foramina, wider rostra, and shorter nasals. In color, they more closely resemble the two specimens from Socna but are slightly more grayish dorsally and are darker on the ventral surface of the tail. It is apparent that these two specimens from the Fezzan represent a population of spiny mice differing significantly from others in Libya. For the present, however, until larger series are obtained from the vicinity of El Barcat and Ghat, in the Fezzan, and more topotypes of *A. c. viator* become available from Tripolitania, these two specimens are provisionally referred to *A. c. viator* largely on the grounds of geographic occurrence.

I have not examined specimens of *Acomys cahirinus seurati* Heim de Balsac, the type locality of which is Iniker, in the Ahaggar Mountains of southern Algeria, but the spiny mice from the Fezzan may represent this subspecies.

Ecological observations. Spiny mice were obtained from areas of loose sand, littered with dead fronds and debris, near the bases of date palms.

According to Thomas (1902, p. 11), spiny mice from the Wadi Sultan near Socna resembled in color "the small blackish stones which lie about among the Soda Mountains." This statement suggests that the habitat in the Wadi Sultan was primarily of a rocky character.

It is possible that these mice occur more abundantly in rocky environments and that the oases may represent marginal habitats. Rocky areas are not uncommon in Libya, but owing to their seemingly desolate and barren appearance, trapping efforts in them are minimal and may account for the sporadic representation of this species in Libya.

According to Setzer (1959), this species is almost exclusively commensal throughout its range in the Nile Valley and Delta. In Libya, spiny mice apparently have not developed this intimate relationship with man, although frequently gerbils (*Gerbillus*) and jirds (*Meriones*) were purchased from the local inhabitants of the oases and had presumably been living commensally with them.

## Family Gliridae

### Genus *Eliomys* Wagner

#### *Eliomys quercinus* (Linnaeus)

*Mus quercinus* Linnaeus, Syst. Nat., 12th ed., vol. 1, p. 84, 1766 (Germany).

General distribution of species. Europe, western U.S.S.R., Sicily, Corsica, Sardinia, Balearic Islands, Turkey, Saudi Arabia, Syria, Israel, Sinai, and North Africa, including Egypt, Libya, Algeria, Morocco, and Spanish Sahara (Rio de Oro).

Distribution in Libya. Northern Cyrenaica, northwestern Tripolitania, and the Fezzan.

Distribution of the subspecies in Libya.

*Eliomys quercinus cyrenaicus*. Cyrenaica: Cyrenaican Plateau and adjacent coastal plain.

*Eliomys quercinus denticulatus*. Fezzan: Large oases and adjoining areas.

*Eliomys quercinus tunetae*. Tripolitania: Tripolitanian Gebel.

Published records in Libya. Cyrenaica: Gheminez (Festa, 1921); Benghazi (Hartert, 1923); Tripolitania: Gharian (Klaptocz, 1909 [*Eliomys munbyanus tunetae* Thomas]); "Gebel Tripolitano" (Toschi, 1951 [*Eliomys munbyanus munbyanus* Pomel]).

Remarks. Owing to the relatively few specimens available to workers in the past, a variety of names has been applied to the dormice of western Libya and Algeria, and the systematic position of this group has never been firmly established. Thomas (1903) described *Eliomys lerotinus tunetae* from Karouana, Tunisia, and stated that it might prove to grade into the earlier described *Eliomys munbyanus* (Pomel) of Morocco and western Algeria. A few years later, Klaptocz (1909) confirmed Thomas' suspicion and regarded *E. l. tunetae* as a subspecies of *E. munbianus* (=*E. munbyanus*), based on specimens from Gharian, Tripolitania. These specimens

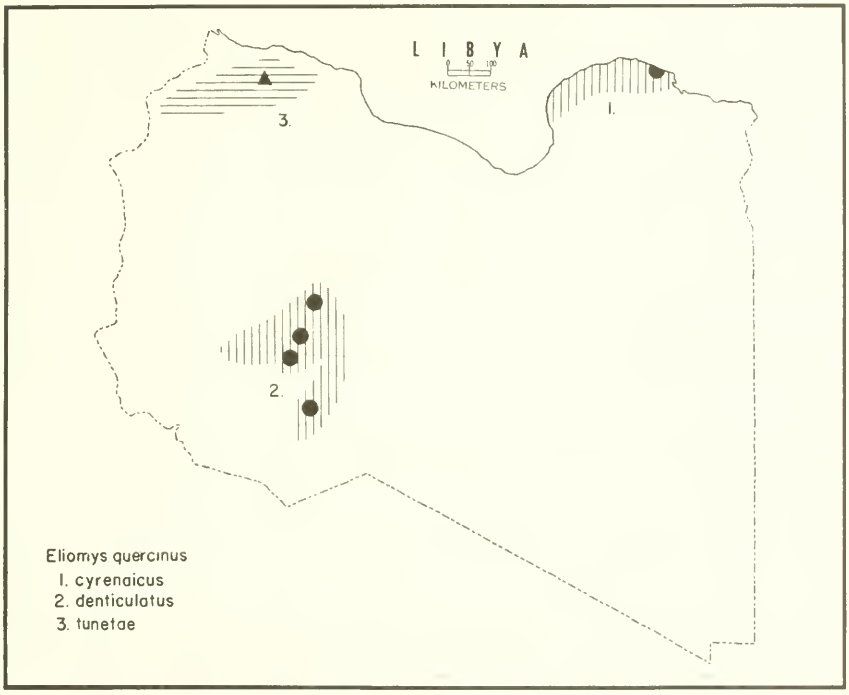


FIGURE 47.—Distribution of the subspecies of *Eliomys quercinus*. Circles indicate specimens examined; triangle indicates published record.

from northern Tripolitania constituted the first record of occurrence of dormice in Libya.

Since that time, *E. m. tunetae* has been regarded as a subspecies of *E. lerotinus* (Lataste) (Zavattari, 1934), regarded as a subspecies of *E. munbyanus* (Ellerman, 1941), or considered as a pure synonym of *E. m. munbyanus* (Cabrera, 1932; and Allen, 1939). Toschi (1951) was in agreement with Cabrera and Allen and assigned specimens from the Tripolitanian Gebel to *E. m. munbyanus*. Ellerman and Morrison-Scott (1951) included all dormice of the genus *Eliomys*, exclusive of *Eliomys melanurus* (Wagner) of Egypt and the Middle East, as a single species, *Eliomys quercinus*, and regarded *E. m. tunetae* as a synonym of *Eliomys quercinus munbyanus*. Toschi (1954) and Setzer (1957), although they examined no actual specimens, considered the dormice of western Tripolitania to represent *E. q. munbyanus*.

The systematics of the dormice of Cyrenaica have undergone less confusion in the literature. Specimens from Gheminez were originally described as a full species, *Eliomys cyrenaicus* (Festa, 1921). Later *E. cyrenaicus* was relegated to subspecific rank under *Eliomys lerotinus*

(Zavattari, 1934), regarded as a subspecies of *E. munbyanus* (Allen, 1939), reinstated as a full species, *E. cyrenaicus* (Ellerman, 1941), and more recently regarded as a subspecies of *E. quercinus* (Ellerman and Morrison-Scott, 1951; Toschi, 1954; Setzer, 1957).

The most recent attempt to clarify the nomenclature of dormice of the genus *Eliomys* is that of Niethammer (1959), in which he united all members of the genus into a single species, *Eliomys quercinus*, which he divided into the "*quercinus*," "*lusitanicus*," and "*melanurus*" groups, based entirely upon the pattern of coloration on the ventral surface of the tail. He recognized two subspecies of *E. quercinus* in Libya, *E. q. cyrenaicus* of northern Cyrenaica, and *E. q. tunetae* of northwestern Tripolitania, the latter again being considered as distinct from *E. q. munbyanus*. These two subspecies, in addition to *E. q. melanurus* of coastal Egypt, Sinai, and the Middle East, constitute the "*melanurus*" group. The "*quercinus*" group is distributed over most of Europe, western U.S.S.R., and extends into North Africa including Morocco and western Algeria. The range of the "*lusitanicus*" group includes southern Spain and Italy and several of the larger islands in the Mediterranean.

In the present work, I have followed Neithammer's classification by including all Libyan dormice within the "*melanurus*" group but have extended appreciably the range of *E. quercinus* to include the Fezzan.

### *Eliomys quercinus cyrenaicus* Festa

*Eliomys cyrenaicus* Festa, Boll. Mus. Zool. Anat. Comp. Univ. Torino, vol. 36, no. 740, p. 4, December 1921 (Gheminez, Cyrenaica).

Specimens examined. One, from 5 km SE Derna, Cyrenaica (skin, skull and skeleton).

Measurements. The measurements of the above specimen, a subadult female, 302274, are: Total length 211; length of tail 100; length of hind foot 27; length of ear 25; greatest length of skull 31.9; condyloincisive length of skull 29; length of audital portion of auditory bulla 9.9; crown length of upper molariform toothrow 5.4; least interorbital breadth 4.2; greatest breadth across zygomatic arches 17.9; length of nasals 11.4; breadth of braincase 14.6.

Diagnosis. Upperparts Avellaneous with strong suffusion of gray, becoming paler, more grayish, on sides; dorsal portion of rostrum and interauricular area grading from Buckthorn Brown to Tawny-Olive; cheeks, mystacial, subauricular, and scapular areas Pale Pinkish Buff; area between eye and origin of vibrissae, entire eye ring, and a broad band passing from eye to base of the pinna of the ear, black with mild suffusion of gray; postauricular patches indistinct; pinna of ear moderate in size, sparsely haired, approaching the color of the pelage of the dorsum, and with a conspicuous tuft

of buffy hairs on anteroventral margin; vibrissae relatively long with white and black individual hairs; fore and hind feet relatively small with four and five functional digits respectively, white above and naked below, with prominent palmar and plantar pads; tail medium in length and with dense covering of grayish-brown hairs proximally and of black hairs distally both above and below, the latter color present throughout terminal four-fifths of the length. Skull: Small and gracile; rostrum narrow and attenuated; interorbital region markedly constricted; parietals noticeably inflated; interparietal expanded laterally; zygomata bowing slightly laterally; auditory bullae conspicuously inflated ventrally; basioccipital broad and triangular; pterygoid processes fragile; hamular processes applied to anteromedial surfaces of the auditory bullae; pterygoid region with numerous large foramina; molariform teeth large, with two prominent cusps on the labial surfaces; anterior palatine foramina large and laterally expanded posteriorly; mandible with a small oval foramen in the angular process.

Comparisons. From *Eliomys quercinus melanurus* Wagner as known from the vicinity of St. Catherine's Monastery, Sinai, the specimen, 302274, from five kilometers southeast of Derna, differs in much smaller size, both cranially and in external dimensions, relatively larger and wider molariform teeth, smaller size of the auditory bullae, and smaller size of the foramen on the angular process of the mandible. In color, this specimen from Cyrenaica closely resembles representatives of *E. q. melanurus* but is slightly darker dorsally. The pinnae of the ears of the specimen from Derna are much smaller and in this respect differ strikingly from those of the representatives of *E. q. melanurus*.

The specimen from Derna differs markedly from a representative (BM, no. 22.5.30.45) of *Eliomys quercinus munbyanus* from Tagouidert (Haha), Morocco, in having more subdued dorsal color, ventral surface of the tail black rather than white, much larger molariform teeth, and a smaller foramen in the angular process of the lower jaw.

According to Festa (1921), *Eliomys cyrenaicus* (=*Eliomys quercinus cyrenaicus*) differs from *Eliomys lerotinus tunetae* (=*Eliomys quercinus tunetae*) primarily by larger body and larger auditory bullae.

For comparison of this specimen from Derna with those representing *Eliomys quercinus denticulatus* from the Fezzan, see the account of *E. q. denticulatus*.

Remarks. This specimen from near Derna, a specimen from Benghazi (Hartert, 1923), and the type series of *E. q. cyrenaicus* from Gheminez constitute the only records of occurrence of dormice in Cyrenaica. Dormice are unknown from farther south in the interior of Cyrenaica, although suitable habitat is present in the larger oases,

such as Gialo, Tazerbo, and Cufra. Also they apparently do not occur in the desert regions of Egypt farther east. The desolate areas of the Serir of Calanscio and the immense dunes of the Sand Sea of Calanscio in Libya and comparable areas of desolation in the Western Desert of Egypt apparently have proven to be insurmountable barriers to the dispersal of dormice, both at present and in the past.

The exact type locality of *E. cyrenaicus* is in doubt. Festa (1921) did not state whether the type series was taken from the local gardens of Gheminez or from the nearby Gebel. A dried up dormouse was found in the gardens of Benghazi by Hartert (1923), and since these gardens are also common at Gheminez, it seems most likely that the specimens came from within, or very near, the village. Setzer (1957) considered it most likely that the type series was collected from the massif some 40 kilometers east of Gheminez, particularly since dormice are unknown to the local residents of Gheminez.

According to Setzer (1957), the specimen from near Derna was live-trapped from the upper slopes of a large wadi near the brink of the coastal escarpment. The vegetative cover at this site consisted of bushlike chaparral, and the dormouse was taken from a trap set near the base of a large evergreen bush.

In the present work, traps were frequently set throughout these chaparral habitats on the Cyrenaican Plateau, but we were unsuccessful in obtaining additional dormice and observed no indications of their presence.

***Eliomys quercinus denticulatus*, new subspecies**

Holotype. Adult female, skin and skull, USNM 322757, from El Gatrun, Fezzan Province, Libya, obtained Jan. 11, 1962, by G. L. Ranck, original no. 1289.

Specimens examined. Six, from Fezzan: Temenhint, 3 (immature); Goddua, 1 (skin, skull and skeleton); 28 km E Murzuch 1 (immature); El Gatrun, 1 (skin, skull and skeleton).

Measurements. Measurements of an adult male from Goddua, 322758, and of the type specimen (in brackets) from El Gatrun, are respectively: Total length 200, [213]; length of tail 96, [115]; length of hind foot 27, [25]; length of ear 24, [24]; greatest length of skull 30.7, [31.2]; condyloincisive length of skull 27.7, [28.3]; length of audital portion of auditory bulla 10.1, [10.5]; crown length of upper molariform toothrow 4.7, [4.5]; least interorbital breadth 4.3, [4.4]; greatest breadth across zygomatic arches 18.1, [17.6]; length of nasals 10.6, [11.2]; breadth of braincase 14.8, [14.7].

Diagnosis. Upperparts Avellaneous, heavily washed with gray, becoming paler on sides and approaching Light Grayish Olive; dorsal part of rostrum and interauricular area more brightly colored than dorsum near Light Pinkish Cinnamon and Cinnamon-Buff; cheeks,

mystacial, subauricular, and scapular areas nearly pure white and sharply contrasting with black areas around eyes and base of ear; postauricular patches inconspicuous and Pale Pinkish Cinnamon strongly suffused with gray; pinna of ear moderate in size, sparsely haired, approaching color of the dorsum, and with a conspicuous tuft of buffy hairs on the anteroventral margin; vibrissae relatively long with white and black individual hairs; fore and hind feet relatively small with four and five functional digits respectively, white above and naked below with prominent palmar and plantar pads, tail relatively long with three distinct zones of color on both surfaces; a proximal region of grayish-brown, a more extensive middle region of black, and a terminal tuft of white. Skull: Small and gracile; rostrum narrow and attenuated; interorbital region markedly constricted; parietals prominently domed; zygomata bowing slightly laterally; auditory bullae conspicuously inflated ventrally; basioccipital broad and triangular; pterygiod region with numerous large foramina; molariform teeth small, with two prominent cusps on the labial surfaces; anterior palatine foramina large and laterally expanded posteriorly; mandible with large oval foramen in the angular process.

Comparisons. From representatives of *Eliomys quercinus melanurus* Wagner from the Gebel Musa and near St. Catherine's Monastery, Sinai, the type specimen of *Eliomys quercinus denticulatus* from El Gatrun, Fezzan, differs in markedly smaller size, particularly the ears which are strikingly smaller; more domed braincase; much shorter molariform toothrow and smaller individual teeth; longer interparietal and a more truncated dorsal margin of the foramen magnum; dorsum slightly darker with greater suffusion of light brownish hairs, especially in the interauricular and rostral regions; postauricular patches more conspicuous; tail white terminally, rather than black, and darker proximally owing to a greater duffusion of brown. In *E. q. denticulatus,* there is a more gradual transition from the brownish-gray color of the base of the tail to the solid black of the middle and distal portions, whereas in *E. q. melanurus* the grayish color of the base of the tail transforms abruptly into black.

Compared to a representative of *Eliomys quercinus cyrenaicus* Festa from five kilometers southeast of Derna, Cyrenaica, the type specimen of *Eliomys quercinus denticulatus* from El Gatrun differs in having skull smaller, interparietal longer, braincase more domed, rostrum narrower and more attenuated, anterior palatine foramina slightly wider, foramen in the angular process of the mandible larger, molariform toothrows markedly shorter, and with smaller individual teeth. These two subspecies are comparable in external dimensions except for the longer tail of *E. q. denticulatus,* which is white terminally, rather than black as in *E. q. cyrenaicus.* They are also similar in dorsal

color, but *E. q. denticulatus* is slightly paler in the interauricular and rostral areas and has less suffusion of buff on the cheeks and scapular areas.

The type specimen of *E. q. denticulatus* from El Gatrun can be readily distinguished from a representative of *Eliomys quercinus munbyanus* from Tagouidert (Haha), Morocco, by much more subdued dorsal color (Avellaneous as opposed to Tawny or Russet) and paler facial region with less black enveloping the base of the pinna of the ear. In *E. q. denticulatus* the ventral surface of the tail is black except for a terminal white tuft, whereas in *E. q. munbyanus* it is white throughout its entire length. The type specimen of *E. q. denticulatus* from El Gatrun is smaller in all external dimensions, except the length of the tail, and has a more domed braincase, a narrower and more attenuated rostrum, slightly more laterally and ventrally inflated auditory bullae, and shorter molariform toothrows with smaller individual teeth.

From a specimen of *Eliomys quercinus tunetae* from Bône, northern Algeria, the specimen of *E. q. denticulatus* is more subdued in dorsal color and is paler in the facial region. Cranial comparisons with this specimen of *E. q. tunetae* from Bône, Algeria, are not possible, but compared with measurements of the type specimen of *Eliomys lerotinus tunetae* (=*Eliomys munbyanus tunetae*) from Karouana, Tunisia, as given by Thomas (1903) in the original description, the type specimen of *E. q. denticulatus* from El Gatrun is slightly smaller in size of skull and has a markedly shorter molariform toothrow. The slightly smaller cranial size of the type specimen of *E. q. denticulatus* is further indicated by comparison of its cranial measurements with those of a specimen representing *E. q. tunetae* from Gherran (=Gharian), Tripolitania, as reported by Klaptocz (1909).

Remarks. The few specimens available at the present time probably do not demonstrate the full range of variation in the Fezzanese population, but because they differ strikingly in morphological characters from all other subspecies of *E. quercinus*, and owing to their isolated geographic position, they warrant designation as a new subspecies.

The most distinguishing features of this new subspecies of dormouse are the small molariform teeth, the relatively long tail with the white tip, and the generally smaller size. The immature specimens from Temenhint and near Murzuch show these same characters.

These specimens from the Fezzan represent the first records of dormice from the Saharan interior of Libya. The specimen from El Gatrun is perhaps the southernmost record for *Eliomys quercinus* in the interior of North Africa and closely approaches the southern limits of distribution for the species on the African continent.

The presence of dormice in the Fezzan is inexplicable in view of the present physiography and climate of Libya. The various populations within the Fezzan are separated from neighboring populations by vast areas of unsuitable habitat, and the Fezzanese population, as a whole, is geographically and physiographically isolated from populations of dormice on the Tripolitanian Gebel nearer the coast. These dormice of the Fezzan probably represent relicts of a former period in Libya when a more humid climate prevailed and habitats suitable for dormice were more widespread and thus permitted their southward dispersal.

Ecological observations. In the Fezzan, dormice seem to be confined largely to the environs of the oases. At Temenhint and 28 kilometers east of Murzuch, young dormice were taken, along with gerbils and jerboas, from areas of loose sand covered with fronds at the bases of young, unpruned date palms, as well as from sandy-clay soils at the bases of hardened mounds which supported sparse growths of tamarix. At Goddua, an adult dormouse was trapped from the midst of a group of young palms into which dunes of considerable size were encroaching. The specimen from El Gatrun was obtained from the edges of a large clump of tamarix located several kilometers from the palm groves of the oasis. In the tamarix zone, an individual clump is usually separated from others by several hundred meters of barren sand alternating with hard-packed clay. It is possible that in this type of habitat dormice are confined to single clumps and utilize tamarix as their sole source of food. A species of dipodil (*Gerbillus amoenus*) was the only other species of rodent obtained from these outlying concentrations of tamarix.

All specimens were obtained during the winter months when nighttime temperatures frequently dropped below 30° F. These low temperatures may account for the sporadic representation of dormice in the Fezzan, as they are known to hibernate during prolonged cold periods.

The name *denticulatus*, from the Latin meaning small teeth, refers to the diminutive size of the molariform teeth in members of this subspecies.

### *Eliomys quercinus tunetae* Thomas

*Eliomys lerotinus tunetae* Thomas, Ann. Mag. Nat. Hist., ser. 7, vol. 2 p. 495, May 1903 (Karouana, Tunis).

Remarks. In Libya, the range of this subspecies is apparently confined to the Tripolitanian Gebel. Klaptocz (1909) assigned specimens from Gharian to *Eliomys munbianus* (*munbyanus*) *tunetae*, and later, Toschi (1951) referred a specimen from the "Gebel tripolitano" to *Eliomys munbyanus munbyanus*. More recently, Neithammer (1959) reinstated *E. m. tunetae* as a subspecies of the widely ranging *Eliomys quercinus*.

I have not examined these specimens from the Tripolitanian Gebel, but because the descriptions of these specimens given by Klaptocz and Toschi agree quite closely with the original description of *Eliomys lerotinus tunetae* (=*Eliomys quercinus tunetae*), and on account of geographic proximity, they are here referred to *E. q. tunetae*.

## Family Dipodidae

### Genus *Jaculus* Erxleben

Jerboas in Libya show varying amounts of geographic variation depending upon the species. *Jaculus jaculus* has undergone the greatest amount of differentiation associated with geographic distribution. The other two species, occurring in Libya, *Jaculus orientalis* and *Jaculus deserti*, are less variable morphologically. The latter two species are represented by samples of relatively small size and, in some cases, the full range of variation for any given character may not be accurate. In jerboas, as with gerbils, geographic variation is usually not manifested by ordinary meristic and quantitative characters, such as external measurements and cranial indices, but is indicated by more subtle, qualitative differences, which do not ordinarily lend themselves to measurement or statistical analysis. The most important of these characters associated with geographic variation include differences in color, shape and configuration of the auditory bullae, angularity and massiveness of the skull and zygomata, and changes in the degree of doming of the braincase.

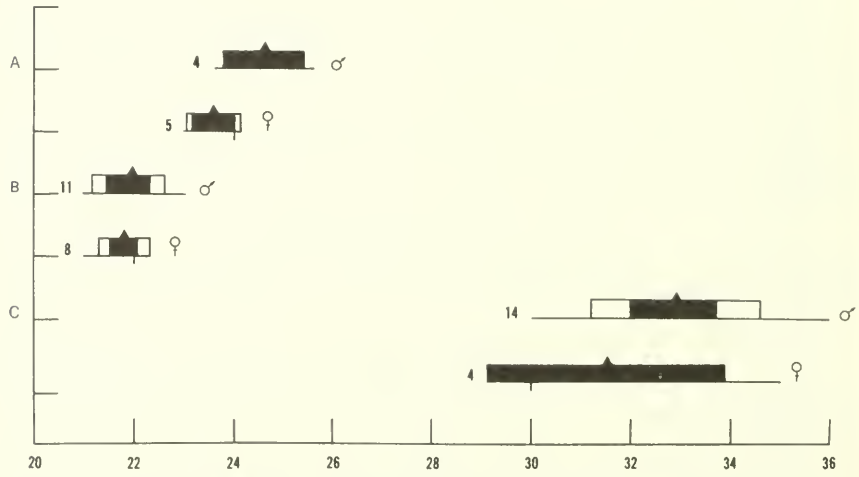


FIGURE 48.—Statistical comparison of length of ear of the species of *Jaculus:* A, *J. deserti;* B, *J. jaculus;* C, *J. orientalis.*

## Key to the Jerboas of Libya

1. Ears usually more than 40 mm; four toes on hind foot; rudimentary premolar present in upper jaw . . . . . **Allactaga tetradactyla**
   Ears usually less than 40 mm; three toes on hind foot; rudimentary premolar lacking in upper jaw . . . . . 2
2. Body size large, hind foot greater than 70 mm; baculum with pair of curved terminal spines . . . . . **Jaculus orientalis**
   Body size small, hind foot less than 70 mm; baculum lacking pair of terminal spines . . . . . 3
3. Dorsal color dark; two foramina on angular process of mandible; sole of hind foot and metatarsal area suffused with brownish hairs . . . . . **J. deserti**
   Dorsal color pale; a single foramen on angular process of mandible; sole of hind foot and metatarsal area white or buff and lacking suffusion of brownish hairs . . . . . **J. jaculus**

### *Jaculus deserti* (Loche)

*Dipus deserti* Loche, Explor. Alger. 100, 1867 (Ouargla district, northern Algerian Sahara).

*Jaculus jaculus deserti* Ellerman, J. R., and T. C. S. Morrison-Scott, Checklist of Palaearctic and Indian Mammals, 1758–1946. Brit. Mus. (Nat. Hist.). p. 539, 1951.

General distribution of species. Arabia, Iraq, Israel, Sinai, Egypt, Libya, and Algeria.

Distribution in Egypt. Sinai, Eastern Desert, and coastal environs west of the Nile.

Distribution of the subspecies in Egypt.

*Jaculus deserti schlüteri* (Nehring). Sinai: St. Catherine's Monastery Area; Wadi Raha; Feiran Oasis; Eastern desert governorate: Cairo-Suez Road; Cairo Area; Gebel el Ahmar; Wadi Ghuweibba; beginning of Wadi el Asyuti; Digla, near Cairo; Ain Sukhna.

Distribution in Libya. Coastal areas of the Gulf of Sirte, the northeastern Libyan coast, and the great hamadas of central Tripolitania and western Cyrenaica.

Distribution of the subspecies in Libya.

*Jaculus deserti favillus.* Cyrenaica and Tripolitania: Littoral deserts near the Gulf of Sirte and northern Cyrenaican coast.

*Jaculus deserti fuscipes.* Tripolitania: Interior and coastal hamadas.

*Jaculus deserti rarus.* Cyrenaica: Extreme southeastern Cyrenaica.

*Jaculus deserti vastus.* Cyrenaica: Interior hamadas of central-western Cyrenaica and the Gebel el Harug el Asued.

Distribution in Algeria. Northern Sahara, including the High Plateaus and the Saharan Atlas.

Distribution of the subspecies in Algeria.

*Jaculus deserti deserti.* Vicinity of Ouargla between the Grand Erg Oriental and the Grand Erg Occidental, and Biskra in the Saharan Atlas.

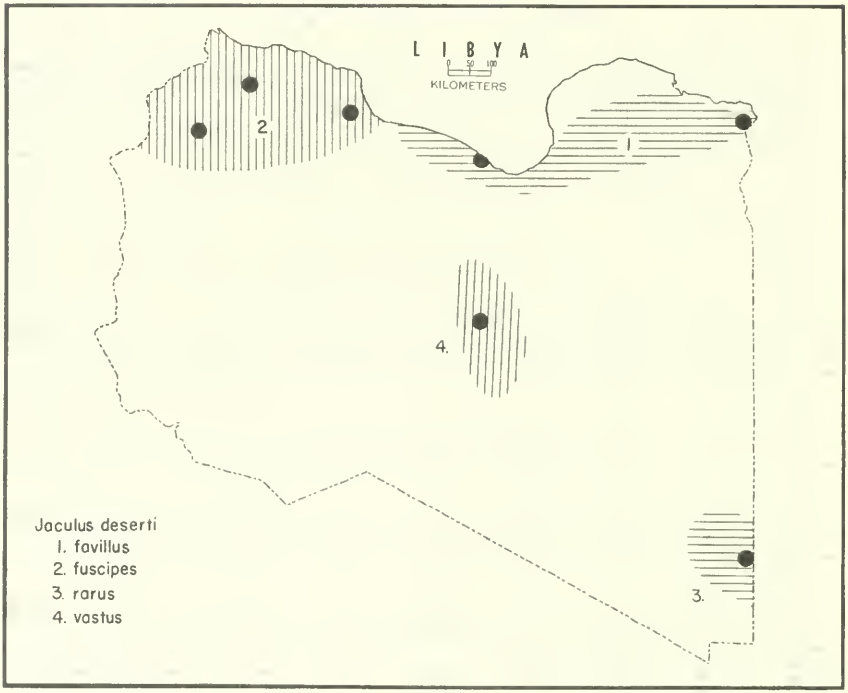


FIGURE 49.—Distribution of the subspecies of *Jaculus deserti*.

COMPARISONS. Representatives of *Jaculus deserti* can be distinguished from those typical of *Jaculus jaculus* by their darker color of sides and dorsum and soles of hind feet, smaller and more compact skulls, larger and more inflated auditory bullae, and the presence of two distinct foramina of comparable size in the angular process of the mandible.

From *Jaculus orientalis*, *J. deserti* differs in smaller size of body and cranium, absence of terminal spines of baculum, slightly lighter coloration of dorsum, and the presence of two distinct foramina in the angular process of the lower jaw.

REMARKS. *Jaculus deserti* was originally described as a full species, *Dipus deserti* (Loche, 1867). Subsequently, this species was relegated to a subspecies of the more widely distributed *Jaculus jaculus* (Ellerman and Morrison-Scott, 1951).

In the past, the small jerboas of Libya were thought to be represented by two subspecies, *J. j. jaculus* and *J. j. deserti*, with large geographic ranges ascribed to each. The range of *J. j. jaculus* was confined to Egypt, Palestine, Arabia, and eastern Libya, and that of *J. j. deserti* included Algeria, Tunisia, and central and western Libya. *Jaculus jaculus deserti* was distinguished from the nominate

subspecies by its proportionately larger auditory bullae and generally smaller size of most cranial and external measurements (Ellerman and Morrison-Scott, 1951; and Toschi, 1951). At this time, comparatively few areas in Libya were represented by specimens, and the above assignments were based largely on geographic occurrence with little regard for taxonomic relationships. Zavattari (1934, p. 896) recorded both *J. j. deserti* and *J. j. jaculus* from El Agheila on the Cyrenaican Coast. The occurrence of these two subspecies in the same geographic area clearly violates the concept of subspeciation. Setzer (1957), the most recent worker in Libyan mammals, had no specimens of the lesser jerboa available and accordingly was unable to investigate this problem. In the present study, adequate series are available from widely scattered localities and thus provide an opportunity to clarify the taxonomic status of the small jerboas of Libya.

No topotypes of *J. j. deserti* are available for study, but Loche (1867, pp. 100–101), in the original description, described this jerboa as follows: "Head short, terminated by a small muzzle; eyes black and shining, ears medium and taking their origin from a white patch; pelage of the upper parts a pale dun color, slightly tinted with black on the rump, resulting from the blackish tips of the otherwise dun-colored hairs; hairs of the sides of the body and flanks white, terminated by tawny and brownish hairs; face, outer parts of shoulders, thighs and ventral surface of tail uniformly dun-colored; posterior surfaces of hind limbs, pencil and plantar surfaces of the hind feet a tawny-brownish color; upper eyelids, sides of the muzzle, all of the front limbs, all underparts and inner surfaces of the hind feet are white; a line of this same color extends ventrally along the tail to the terminal brush, which is brown and white; nails white; total length 310 mm., length of tail 170 mm." Loche (1867) indicated that *Dipus deserti* (=*Jaculus jaculus deserti*) was a miniature reproduction of *Dipus gerboa* Olivier (=*Jaculus orientalis*).

Representatives of *J. j. deserti* from Biskra, Algeria, agree closely with the above description and are found to differ from typical *J. j. jaculus* in a number of additional characters, particularly in having brownish rather than white hairs in the soles of the feet, much darker dorsal color, and two foramina in the angular process of the lower jaw, instead of one as in *J. j. jaculus*. Furthermore, in several localities in Libya, jerboas of the *deserti* type and those typical of *J. j. jaculus* occur sympatrically and show no evidences of interbreeding. The present work indicates that *J. j. deserti* is sufficiently distinct to warrant reinstatement as a full species, and because of priority (1867), assumes precedence as the nominate form. The extralimital forms *Jaculus loftusi vocator* Thomas, 1921 (type locality: Sohar, Muscat,

Arabia); *Dipus schlüteri* Nehring, 1901 (type locality: Jaffa, Palestine); and *Dipus loftusi* Blanford, 1875 (type locality: Mohumrah, Iraq) were referred to *Jaculus jaculus* by Ellerman and Morrison-Scott (1951, p. 539). I have, however, found that these forms definitely have characters which ally them to the "*deserti*" type and consider them as subspecies of *J. deserti* rather than *J. jaculus*. Henceforth, these forms should be known as *Jaculus deserti vocator* Thomas, *Jaculus deserti schlüteri* (Nehring), and *Jaculus deserti loftusi* (Blanford).

Although intergradation is not demonstrable between populations of *Jaculus deserti favillus* and *Jaculus deserti fuscipes* in Libya, the ranges of these two subspecies are not separated by physical barriers. In the future, when more adequate series become available, this intergradation will probably become apparent, and clinal gradients will be demonstrable within these two widely distributed populations. Farther east, however, the Nile River appears to serve as an effective barrier for the exchange of genes between *J. d. favillus* and *Jaculus deserti schlüteri*.

*Jaculus deserti*, in the dark color of dorsum and soles of hind feet, resembles *Jaculus blanfordi* (Murray), whose range lies far to the east and north. This similarity in color is probably the result of convergence or a response to a similar color of substrate. Vast areas of gray and brown hamadas are of common occurrence in the ranges of both of these jerboas. Morphologically, *J. blanfordi* is more closely related to the larger Egyptian jerboa (*J. orientalis*).

Ecological observations. Four distinct populations comprise this species in Libya. *Jaculus deserti favillus* is apparently confined to the more humid Mediterranean coast and adjacent areas of low elevation. *Jaculus deserti vastus*, *J. d. rarus* and *J. d. fuscipes* prefer the more arid deserts of the interior. In general, this species of jerboa is more confined to the "hamadas" or great "pebble deserts" of the Libyan hinterland. In the interior hamadas, vegetation may be entirely wanting or confined to narrow strips along the margins of wadis, the brinks of escarpments, or the fringes of inland "playas." The larger wadis sometimes support stands of acacia of appreciable size, but these are of rare and local occurrence.

Near the coastal plain at Marble Arch, *J. jaculus* and *J. deserti* occur together. In other coastal areas the large Egyptian jerboa (*J. orientalis*) also occurs sympatrically with these smaller species.

#### *Jaculus deserti favillus* Setzer

*Jaculus jaculus favillus* Setzer, Proc. Biol. Soc. Washington, vol. 68, p. 184, Dec. 31, 1955 (Bir Bosslanga; Salum, Western Desert Governorate, Egypt).

Specimens examined. Two, from Cyrenaica: 10 km SW Fort Capuzzo, 1; from Tripolitania: 15 km WNW Marble Arch, 1.

Measurements. Measurements of the above specimens, an adult male, 325806, and an adult female, 325819, are, respectively: Total length 300, 312; length of tail 186, 195; length of hind foot 63, 60; length of ear 24, 23; greatest length of skull 34.7, 33.8; condyloincisive length of skull 30.5, 30.6; crown length of upper molariform toothrow 5.2, 5.5; greatest breadth across zygomatic processes 23.5, 23.2; least interorbital breadth 13, 12.8; length of nasals 13.2, 12.5; breadth of rostrum at level of antorbital foramina 5.5, 4.5; greatest breadth of braincase 19.1, 18.5; greatest breadth across antorbital processes 24.4, 24.1.

Diagnosis. Upperparts, including dorsum of tail, Avellaneous becoming darker posteriorly owing to greater admixture of brown-tipped hairs; interorbital and interauricular areas Cinnamon-Buff; mystacial, suborbital, postauricular, and pectoral areas Light Buff; pinna of ears badly disfigured by ants, but remnants Clay Color; in both specimens Plumbeous underfur exposed in large eroded patches on dorsum behind ears; underparts white grading to Light Buff on lateral margins; lateral margins of rump creamy and washed with flecks of gray; prominent whitish bands on the posterolateral areas of the rump converge medially onto the tail; fore and hind feet white dorsally, forefeet naked ventrally; soles of hind feet heavily furred ventrally with strong admixture of Light Pinkish Cinnamon; tail prominently bicolored and pinnate, Avellaneous dorsally and Pale Pinkish Buff ventrally; pinna Bister proximally and white distally; vibrissae profuse and dark basally. Skull: Large for the species; auditory bullae large and markedly inflated; zygomata heavy, relatively flattened in profile; angular process of mandibles fragile and with two distinct foramina of unequal size on anterior margin.

From near topotypes of the nominate subspecies from Biskra, Algeria, these two specimens from Libya are larger in all external measurements and cranial characters, being of comparable size only in the length of the ears.

These two specimens differ from *Jaculus deserti schlüteri* as known from Feiran Oasis, Sinai, Egypt, as follows: Size: Smaller in all external measurements, especially in length of hind foot and length of ear. Skull: Smaller in greatest length, condyloincisive length, and breadth of rostrum at level of antorbital foramina; larger in length of molariform toothrow, least interorbital breadth, and size and degree of inflation of auditory bullae. Color: Slightly paler and less variegated dorsum, supraorbital and rostral areas more uniformly colored Cinnamon Buff, and soles of feet with less suffusion of dark hairs.

The specimens from Libya, although clearly referable to *J. d. favillus*, differ from topotypes of the latter in having slightly shorter ears, paler color of dorsum, longer molariform toothrows, greater least interorbital breadth, and the two foramina of the angular process larger, more distinct, and more uniform in size.

For comparisons with *J. d. fuscipes*, *J. d. rarus*, and *J. d. vastus*, see accounts of those subspecies.

Remarks. This subspecies was originally assigned to *J. jaculus* by Setzer (1955) and considered by him to represent an eastward extension of the Libyan fauna into Egypt. The present study indicates, however, that this subspecies has a much wider distribution in Libya and Egypt than was formerly supposed and shows characters allying it with *J. deserti* rather than to *J. jaculus*.

The specimen from Fort Capuzzo was taken alive while making a nighttime check of a trapline which was set in a localized pocket of vegetation in a sandy depression in the otherwise denuded coastal plain. The plants forming these sporadic "pockets" of vegetation were composed of juniperous species and other woody shrubs.

The habitat at Marble Arch is similar to that of the coastal plain at Fort Capuzzo but with more widespread areas of rocky hamada.

*Jaculus deserti favillus* apparently represents a population of jerboas of large size restricted to the more humid environs of the coastal plain and low-lying areas of the Libyan and Egyptian littoral deserts, and it is genetically distinct from those of the Saharan interior. Setzer (1958) suspected that the range of this subspecies was restricted to the humid areas of the Mediterranean coastline.

#### *Jaculus deserti fuscipes*, new subspecies

Holotype. Adult female, skin and skull, USNM 322761, from 7 km S El Gheddahia, Tripolitania Province, Libya; obtained Dec. 3, 1961, by G. L. Ranck, original no. 909.

Specimens examined. Five, from Tripolitania: 20 km E Rumia, 1; 7 km S El Gheddahia, 3; 55 km SW Bir Allagh. 1.

Measurements. Averages and extremes of three females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 287 (285–290), [290]; length of tail 180.7 (173–192), [192]; length of hind foot 61.7 (61–62), [62]; length of ear 23.7 (23–24), [24]; greatest length of skull 34 (33.7–34.4), [34]; condyloincisive length of skull 30.5 (30.2–30.7), [30.2]; crown length of upper molariform toothrow 5.3 (5.3–5.3), [5.3]; greatest breadth across zygomatic processes 22.7 (21.5–23.5), [23.5]; least interorbital breadth 12.4 (12.2–12.6), [12.6]; length of nasals 12.0 (11.7–12.4), [11.8]; breadth of rostrum at level of antorbital foramina 5 (4.6–5.2), [5.2];

greatest breadth of braincase 18.2 (17.6–18.6), [18.4]; greatest breadth across antorbital processes 23.1 (23–23.1), [23.1].

Diagnosis. Upperparts Avellaneous grading into Cinnamon-Buff; supraorbital, interauricular and rostral regions and all parts of dorsum heavily suffused with dark hairs, being particularly concentrated on lateral margins of rump and extending onto flank; sides and scapular region with strong admixture of brownish hairs; entire dorsum thus appearing streaked or variegated in color; mystacial, circumorbital, and small patches near anterior margin of ear Pale Pinkish Buff; entire underparts white, becoming more buffy on ventrolateral surfaces; pinna of ear dark (Drab) on distal margins and anteriorly grading to same color as dorsum of body with a thin row of buffy hairs; vibrissae long, almost as long as body, and dark basally; fore and hind feet white dorsally, the former naked ventrally and bearing five claws; soles of hind feet heavily furred with markedly contrasting inner hairs of Mummy Brown and bearing three claws; tail indistinctly bicolored Avellaneous, dorsally, and ventrally, Light Buff, the latter color becoming whiter distally; distal portion of tail distinctly pinnate and bicolored brownish-black proximally and white distally. Skull: Medium, robust, and compacted; incisors large and heavy; upper molariform toothrow long; rostum wide and short; nasals short; zygomata heavy; braincase moderately vaulted; condyloincisive length long; auditory bullae large and markedly inflated; mandible heavy and angular process of mandible with two distinct foramina of nearly equal size on ventrolateral margin.

Comparisons. Members of this subspecies resemble near topotypes of *Jaculus deserti deserti* from Biskra, Algeria, but differ in their darker color of dorsum and soles of the hind feet, larger hind feet, larger and more distinct foramina on the angular process of lower jaw and slightly larger size of skull.

From specimens of *Jaculus deserti schlüteri* as known from Feiran Oasis, Sinai Governorate, and Wadi Ghuweibba, Eastern Desert Governorate, Egypt, *Jaculus deserti fuscipes* differs in slightly darker color of dorsum and soles of hind feet, smaller body size, markedly smaller hind feet and ears, shorter skull, smaller and less inflated auditory bullae, foramina of angular process larger and more uniform in size, more vaulted braincase, longer molariform toothrow, larger interorbital breadth, shorter nasals, and slightly smaller breadth of braincase.

Compared with specimens representing *Jaculus deserti favillus* from 20 miles west of Sidi Barrani, Western Desert Governorate, Egypt, this subspecies differs in smaller size of all external measurements, being especially smaller in length of ears and hind feet. In color,

*J. d. fuscipes* is slightly darker dorsally with a more prominent admixture of black hairs on lateral margins of rump and darker hairs on soles of hind feet. Cranially, these two subspecies are quite similar, but *J. d. fuscipes* can be distinguished by its longer molariform toothrow, slightly more vaulted skull, more robust zygomata, and larger and more distinct foramina on the angular process.

*Jaculus deserti fuscipes* differs from *Jaculus deserti vastus* in markedly smaller size of external and cranial measurements except length of ear, condyloincisive length of skull, length of molariform toothrow, and greatest breadth of braincase. *Jaculus deserti vastus* is paler and more uniform in color of dorsum with less admixture of dark hairs, lacking blackish hairs on lateral margins of the rump, and is more buffy ventrally.

Remarks. This subspecies of jerboa can be distinguished from all others in Tripolitania by its markedly darker dorsal color, darker hairs on the sole of the hind foot, more compact skull, the presence of two distinct foramina in the angular process, larger and more greatly inflated auditory bullae, and proportionately wider upper incisors.

The range of *Jaculus deserti fuscipes* includes the extensive hamadas of central and northern Tripolitania. Throughout these "pebble deserts," vegetation occurs sporadically in localized concentrations along the margins of dry watercourses and other low-lying areas. These jerboas probably have a much wider distribution in Libya than is currently supposed.

The above specimens were all obtained from these interior hamadas. The type locality, although near the Mediterranean coast, is typical "hamada" desert and has no physical relationship to the nearby coastal plain. Fat-tailed sand rats (*Pachyuromys duprasi*) also show a decided preference for this rocky, upland type of habitat and were obtained at Rumia and El Gheddahia along with jerboas.

The specimens from near Bir Allagh and Rumia are darker dorsally and have a greater suffusion of dark hairs on the soles and metatarsal areas of hind feet than the specimens from the type locality but are definitely referable to this new subspecies.

The subspecific name *fuscipes* refers to the dark-colored soles of the hind feet.

***Jaculus deserti rarus*, new subspecies**

Holotype. Adult male, skin and skull, USNM 319781, from Ain Zueia, Gebel Uweinat, Cyrenaica Province, Libya; obtained Mar. 26, 1961, by H. W. Setzer, original no. 2987.

Specimen examined. The type only.

Measurements. The type specimen measures: Total length 296; length of tail 184; length of hind foot 61; length of ear 24; greatest

length of skull 33; condyloincisive length of skull 29.2; crown length of upper molariform toothrow 4.9; least interorbital breadth 11.6; length of nasals 12.1; breadth of rostrum at level of antorbital foramina 5.1; greatest breadth of braincase 16.9; greatest breadth across antorbital processes 22.

Diagnosis. Upperparts Cinnamon-Buff grading to Light Ochraceous Buff in interauricular and supraorbital regions; rump decidedly darker owing to greater admixture of brown-tipped hairs; plumbeous underfur exposed in many areas of dorsum; rostral, pectoral, cheek, flank, and mystacial areas, and entire venter Pale Ochraceous-Buff; lateral areas washed with darker color; fore and hind feet sparsely haired and white dorsally; ventral surface of hind feet with long tufts of gray hairs; tail indistinctly bicolored, Cinnamon-Buff dorsally, Light Buff ventrally and with a prominent pinna, black proximally and white distally. Skull: Small, zygomata delicate, auditory bullae small and little inflated, rostrum narrow, foramen magnum small, molariform toothrow short, and angular process of mandible with two distinct foramina on its anteromedial surface.

Remarks. This subspecies differs from all other subspecies of *Jaculus deserti* in the smaller size of all cranial and external measurements. The type specimen of *J. d. rarus* resembles the type series of *Jaculus jaculus cufrensis* in body size, greatest length of skull, and condyloincisive length. In crown length of upper molariform toothrow, least interorbital breadth, length of nasals, breadth of rostrum at level of antorbital foramina, size and degree of inflation of auditory bullae, and in external measurements, it is closer to *Jaculus jaculus butleri* Thomas. The above are only superficial resemblances, however, inasmuch as this specimen has two foramina in the angular process of the mandible, brownish hairs on the soles of the hind feet, and markedly darker dorsal coloration with greater suffusion of brownish hairs on the rump and sides. The latter are all diagnostic characteristics of *Jaculus deserti* and, in the aggregate, are unknown in *Jaculus jaculus*.

This single specimen was obtained from the barren hamada at the base of the Gebel near Ain Zueia by Henry W. Setzer, while en route to the Tibesti Mountains in the spring and early summer of 1961. It was obtained only after three successive nights of continuous trapping throughout an area of abundant diggings. Efforts to obtain additional specimens by "night hunting" were without effect.

The extensive sand seas to the north have apparently isolated this subspecies from the ranges of all other populations of *Jaculus deserti*. The small size and other cranial differences of this subspecies may have arisen through the agency of genetic drift and consequent rapid genetic fixation in an effectively small, isolated population of jerboas.

The term *rarus* is from the Latin meaning scarce or scattered and has reference to the apparent scarcity of jerboas of this subspecies.

***Jaculus deserti vastus*, new subspecies**

HOLOTYPE. Adult male, skin and skull, USNM 325837, from Wadi er Rueis, Gebel el Harug el Asued, 340 km WNW Tazerbo Oasis, Cyrenaica Province, Libya; obtained Apr. 29, 1962, by G. L. Ranck, original no. 2116.

SPECIMENS EXAMINED. The type only.

MEASUREMENTS. Measurements of the type specimen are as follows: Total length 311, length of tail 203; length of hind foot 67; length of ear 24; greatest length of skull 34.3; condyloincisive length of skull 30.3; crown length of upper molariform toothrow 5.3; greatest breadth across zygomatic processes 23.6; least interorbital breadth 12.6; length of nasals 12.3; breadth of rostrum at level of antorbital foramina 5.2; greatest breadth of braincase 18.2; greatest breadth across antorbital processes 23.2.

DIAGNOSIS. Upperparts Light Pinkish Cinnamon grading to Pale Pinkish Cinnamon on sides, flanks, pectoral regions, and rostral areas; all upperparts with strong suffusion of brownish-tipped hairs more concentrated on rump; mystacial, circumorbital, subauricular areas, forearms and entire venter, Pale Pinkish Buff; vibrissae long and darkly colored basally; pinnae of ears sparsely haired and white dorsally; forefeet naked ventrally and bearing five claws; hind feet heavily furred ventrally, bearing three claws, and sole with strong suffusion of Mummy Brown hairs. Tail indistinctly bicolored Pinkish Buff dorsally and Light Buff ventrally and with terminal pinna which is Clove Brown proximally and white distally. Skull: Large, auditory bullae large and markedly inflated; zygomata robust; incisors large and heavy; braincase slightly vaulted; ramus of mandible heavily fenestrated and angular process with two distinct oval foramina of unequal size.

COMPARISONS. From representatives of *J. d. deserti* of Algeria, this specimen from the Wadi er Rueis differs in its much larger size, particularly in the length of the hind feet and tail.

*Jaculus deserti vastus* differs from representatives of *Jaculus deserti favillus* from 20 miles west of Sidi Barrani, Western Desert Governorate, Egypt, in slightly longer tail, much larger hind feet, shorter ears, longer molariform toothrow, larger and more uniform foramina on angular process, paler, less variegated dorsal pelage, and more buffy venter.

This specimen closely resembles representatives of *Jaculus deserti schlüteri* from Feiran Oasis, Sinai Governorate, and Wadi Ghuweibba, Eastern Desert Governorate, Egypt, but differs in smaller body size, slightly shorter length of tail, hind feet, and ears, longer molariform toothrow, wider interorbital breadth, shorter nasals, slightly paler, less variegated color of dorsum and more buffy venter.

For comparison with *Jaculus deserti fuscipes*, see account of that subspecies.

Remarks. *Jaculus deserti vastus* can easily be distinguished from all other small Libyan jerboas by its much larger body size, markedly longer tail and hind feet, and much greater suffusion of buffy hairs on the forelegs, sides, and venter.

Although this specimen doubtless belongs to the "*deserti*" group of jerboas, the above differences are of sufficient magnitude to warrant the designation of a new species. Owing to lack of adequate material it is deemed better, however, to limit the category to subspecific rather than specific rank.

The type specimen is the only record of occurrence for this subspecies in Libya. The above specimen was obtained from the rocky, denuded margins of the Wadi er Rueis at a point where it emerges from the higher parts of the Gebel el Harug el Asued (Black Gebel). Volcanic extrusions are widespread in this area and in many places encroach upon the Wadi. Vegetative cover is very limited and is composed primarily of acacias, woody shrubs, and hardy grasses.

This large jerboa probably has a much wider distribution in Libya than the present study would indicate, and its range doubtless includes the entire massif of the "Black Gebel" and the low-lying peripheral areas wherever suitable habitat occurs.

Jerboas inhabiting the Gebel el Harug el Asued are effectively isolated from the ranges of other subspecies of *Jaculus deserti* in Libya. Gene exchange with these other populations is accordingly of infrequent occurrence and genetic fixation and differentiation have thus progressed rapidly. Owing to the remoteness and consequent inaccessibility of central Cyrenaica, additional specimens of this unique jerboa will probably long be wanting.

The name *vastus*, from the Latin meaning empty and waste, alludes to the remote regions inhabited by jerboas of this subspecies.

### *Jaculus jaculus* (Linnaeus)

*Mus jaculus* Linnaeus, Syst. Nat., 10th ed. p. 63, 1758 ("In Arabia, Calmukia"; Giza Pyramids, Egypt [G. Allen, 1939]).

General distribution of species. Iraq, Syria, Lebanon, Israel, Jordan, Saudi Arabia, North Africa southward through the Sahara including Sudan, Chad, Niger, Mauritania, and Spanish Sahara.

Distribution in Libya. Widespread through the coastal and interior areas of Cyrenaica, Tripolitania, and the Fezzan.

Distribution of the subspecies in Libya.

*Jaculus jaculus arenaceous.* Fezzan: Oases and connecting wadis.

*Jaculus jaculus collinsi.* Cyrenaica: Gialo and Tazerbo and the intervening Serir of Calanscio.

*Jaculus jaculus cufrensis.* Cyrenaica: Environs of Cufra Oasis.

*Jaculus jaculus tripolitanicus.* Tripolitania: Gefara plain.

*Jaculus jaculus whitchurchi.* Cyrenaica: Coastal plain of Gulf of Sirte, and Giarabub Oasis.

Published records in Libya. Cyrenaica: Giarabub (de Beaux, 1928); El Agheila, Cufra (de Beaux, 1932); Giarabub (Zavattari, 1937); Zauia Mechili (de Beaux, 1938); Giarabub, Gialo, Marada, Tazerbo (Toschi, 1951); Tripolitania: Socna, "Attich Loumonileh", "Oumsinerma" (Thomas, 1902); Tripoli (Klaptocz, 1909); Sirte (Zavattari, 1937); Tripolitania settentrionale (Toschi, 1951); Fezzan: Murzuch, Serdeles, Bir el Fatima (Toschi, 1951).

Remarks. The present study reveals that jerboas of this species are an assemblage of rather localized populations showing considerable differentiation resulting from relatively long periods of isolation of allopatric populations and ensuing genetic fixation. Local differentiation of these jerboas is demonstrable in several areas in Libya. These areas may be delineated as the oases and serirs of central and southern Cyrenaica, the oases and intervening wadis of the Fezzan, and the littoral deserts along the Gulf of Sirte in Tripolitania. This latter region is divisible into two distinct areas—the broad coastal

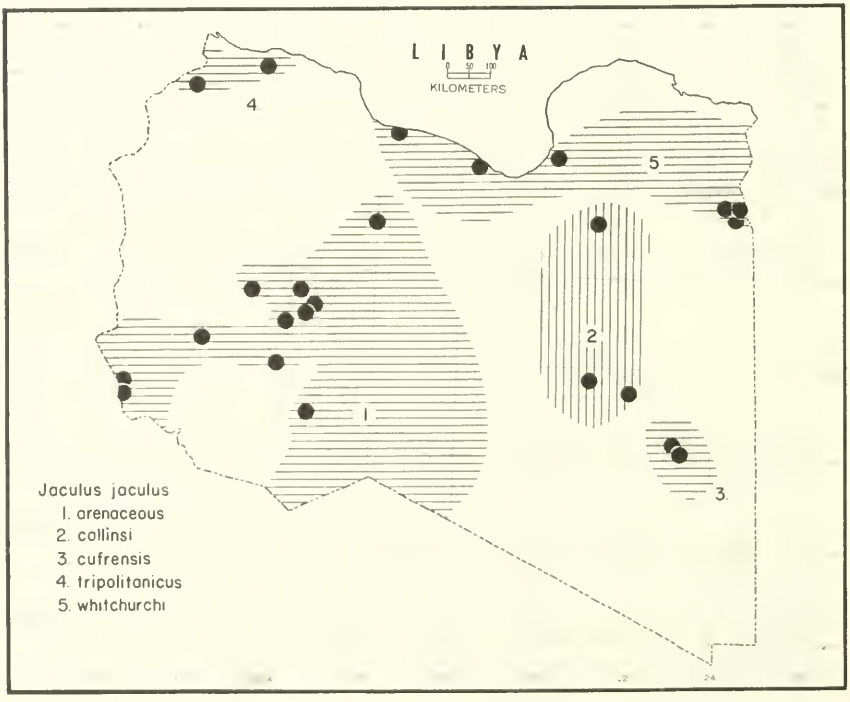


Figure 50.—Distribution of the subspecies of *Jaculus jaculus.*

plain between the Mediterranean Sea and the coastal escarpment and the transitional desert farther inland.

The Sand Sea of Rebianna serves as an effective barrier to gene flow between jerboas inhabiting the oases of Cufra and Tazerbo, and the Sand Sea of Calanscio prevents contact between these populations and those of the nominate subspecies to the north. Genetic interchange between animals from Gialo and those of coastal Libya is of doubtful occurrence owing to extensive sandy plains and dunes interposed between their ranges. Some genetic exchange occurs between coastal and interior populations in the region of the oases of Socna, Hun and Uaddan, but generally, the Fezzanese jerboas have maintained their genetic integrity. In northern Tripolitania, the coastal escarpment effectively separates the jerboas of the coastal plain from those of the "high deserts" of the interior.

Ecological observations. *Jaculus jaculus* inhabits both the littoral deserts and the interior oases of Libya. On the coastal plain they are common in the sandy hummocks and large coastal dunes, and farther inland are confined to the sandy margins of the oases where vegetation occurs sparingly for several kilometers beyond the palm groves of the oasis proper. This peripheral vegetation, composed of *Calligonum*, *Tamarix*, and thorny perennials, is interspersed with barren areas of sandy, rock-strewn plains. Large, solitary hummocks are present in these outlying areas and provide suitable sites for burrow construction above the water table.

Occasionally, jerboas are taken from sandy areas at the bases of date palms and tamarix in the interior of the oasis and occur here with *Gerbillus gerbillus*, *Gerbillus pyramidum*, and *Gerbillus amoenus*.

They are of rare occurrence in rocky deserts and playas far removed from oases. In these latter areas, *J. jaculus* is supplanted by the darker colored *Jaculus deserti*. These two species are known to occur sympatrically along a narrow zone of contact on the inner margins of the coastal plain and probably occur together in other parts of Libya.

Jerboas normally begin foraging shortly after dusk, but when cold temperatures prevail, they emerge from their burrows later in the night. In Libya, prolonged periods of cold are uncommon, hence it is doubtful if jerboas hibernate there. In a few instances, jerboas were taken when temperatures fell below 30° F.

Jerboas are difficult to catch by standard trapping methods, and accordingly trap yield is usually low, thus rendering an incorrect estimate of population size. Jerboas are probably more abundant in Libya than trapping success would indicate.

The pale, ochraceous color of these jerboas is undoubtedly an adaptive response to the prevailing color of the soil on and in which they live. *Jaculus jaculus* is markedly paler in dorsal color than *J. deserti*, which inhabits the grayish brown soils of the hamadas.

285-134 O—68——16

*Jaculus jaculus arenaceous*, new subspecies

Holotype. Adult male, skin and skull, USNM 322812, from Edri, Fezzan Province, Libya; obtained Feb. 9, 1962, by G. L. Ranck, original no. 1624.

Specimens examined. Seventy-one, from Tripolitania: 2 km SW Hun, 5; from Fezzan: Brach, 1; Edri, 23 (2 skeletons); Temenhint Oasis, 30 km NE Sebha, 3; 4 km N Sebha, 1; 3 km NW Sebha, 2; Sebha, 3; 7 km SW Sebha, 1; El Abiad, 60 km SW Sebha, 9; 75 km W Ubari, 2; Murzuch, 5; 55 km SSW Serdeles, 7; El Gatrun, 3; 12 km N Ghat, 3; Ghat, 4.

Measurements. Averages and extremes of 11 adult males and 8 adult females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 289 (279–307), 299.4 (288–308), [307]; length of tail 178.4 (160–200), 182 (172–189), [202]; length of hind foot 63.2 (61–66), 63.3 (62–65), [65]; length of ear 21.9 (21–23), 21.8 (21–22), [23]; greatest length of skull 34.1 (33.5–34.7), 34.3 (32.9–34.8), [34.7]; condyloincisive length of skull 29.9 (28.9–30.8), 30 (28.9–31.4), [30.6]; crown length of upper molariform toothrow 5.2 (4.8–5.6), 5.3 (5.1–5.4), [5.3]; greatest breadth across zygomatic processes 22.1 (21.3–23.6), 22.3 (21–22.8), [22.3]; least interorbital breadth 12.4 (11.8–12.8), 12.4 (11.8–13.2), [12]; length of nasals 12.6 (12–13.4), 12.8 (11.7–14), [14]; breadth of rostrum at level of antorbital foramina 5 (4.8–5.2), 4.9 (4.7–5.3), [5] greatest breadth of braincase 18.1 (17.3–18.7), 18 (17.5–18.7), [18]; greatest breadth across antorbital processes 22.7 (22–23.4), 22.8 (21.7–23.7), [22.3.]

Diagnosis. Upperparts Light Pinkish Cinnamon becoming darker posteriorly with strong admixture of brownish-tipped hairs causing a markedly variegated appearance; rostral, mystacial, circumorbital, postauricular, pectoral, and lateral areas Pale Ochraceous-Buff; entire underparts, dorsal surface of fore and hind feet, and terminal portion of tail white; forefeet naked ventrally and bearing five claws; hind feet relatively large, heavily furred ventrally, artificially stained Pale Yellow-Orange and with three toes; tail indistinctly bicolored Pale Yellow-Orange dorsally and Light Buff ventrally, and terminating in a distinct transversely bicolored pinna, Bister proximally and white distally; pinna of ear Clay Color, sparsely haired with fringe of buff-colored hairs on anteromedial margin. Skull: Large, auditory bullae moderately large and inflated; zygomata convergent anteriorly; pterygoid processes slightly divergent; nasals relatively long; molariform toothrow relatively long.

Comparisons. *Jaculus jaculus arenaceous* differs from the nominate subspecies in greater overall length, less compacted skull, slightly less vaulted braincase, more inflated bullae, larger infraorbital

foramina, longer and more widely flaring nasals, wider rostrum, greater breadth of rostrum at level of antorbital foramina, and longer molariform toothrow. In color, *J. j. arenaceous* differs from topotypes of *Jaculus jaculus jaculus* in more uniform orangish dorsal coloration, less suffusion of dark hairs on sides, darker pinna of ear, and vibrissae of more uniform color.

Compared to the type and type series of *Jaculus jaculus whitchurchi*, *J. j. arenaceous* differs in greater overall length of skull and body, smaller hind feet, less vaulted braincase, more robust zygomata, larger, infraorbital foramina, larger foramen on anterior fossa of angular process and larger size in all other cranial features. In color, jerboas from Edri are darker, more variegated and far less uniformly colored dorsally, have more admixture of dark hairs on the sides, and have a more extensive buffy patch anterior to dark portion of pinna of the tail.

From the type and type series of *Jaculus jaculus collinsi*, *J. j. arenaceous* can be differentiated by its more massive skull, relatively narrower rostrum, larger lachrymals, slightly larger and more inflated auditory bullae, more tenuous pterygoid processes, larger size of all cranial measurements (except greatest breadth across zygomatic processes and greatest breadth of braincase), and markedly larger hind feet. Jerboas from Edri appear darker and more variegated in color owing to greater suffusion of brownish hairs on dorsum, rump, and sides. An old male, 322768, from Temenhint Oasis, 30 kilometers northeast of Sebha, is markedly more orangish (ochraceous) in color of dorsum and probably represents an aberrant specimen or an extreme in pelage color incident to old age.

This subspecies can be easily separated from *J. j. sefrius* Thomas and Hinton from Ain Sefra, southwestern Algeria, by its significantly smaller size of external and cranial measurements.

A single specimen (BM, 12.11.14.53) of *J. j. centralis* Thomas and Hinton from 85 kilometers south of El Golea, central Algerian Sahara, somewhat resembles *J. j. arenaceous* in color, but in external measurements and cranial characters it is much smaller.

For comparisons with *Jaculus jaculus tripolitanicus* and *Jaculus jaculus cufrensis*, see accounts of those subspecies.

Remarks. Specimens from 2 kilometers southwest of Hun are the only known representatives of *J. j. arenaceous* from Tripolitania Province and are intergrades with *J. j. whitchurchi*. In length of upper molariform toothrow, greatest breadth across zygomatic processes, greatest breadth across antorbital processes, and length of the hind foot they resemble the latter subspecies, but in the majority of cranial and external measurements, they are closer to *J. j. arenaceous* to which they are here referred. The vast hamadas to the north and east

of Hun, Socna, and Uaddan provide favorable habitat for jerboas and accordingly allow for genetic exchange between coastal populations and those in the interior.

In Fezzanese populations of jerboas, genetic uniformity has been maintained owing to the continuity of suitable habitat and conesquent free genetic interchange. Numerous dry watercourses such as the Wadi es Sciati, north and west of Sebha, the Wadi Tenezoft, north of Ghat, and the broad hamadas linking together the oases of Tesaua, Murzuch, Traghen, Umm el Araneb, Meseguin, Zuila, and Tmessa provide suitable habitat and insure the maintenance of genetic integrity within and between populations of jerboas in these far-reaching areas. These hamadas and wadis allow jerboas to circumvent the desolate "ramleh" or sandy areas. El Gatrun, however, unlike the aforementioned oases, is effectively isolated by the great sandy areas of the Idehan Murzuch, and three specimens from here show slight differences from populations elsewhere in the Fezzan. Until such time as adequate series become available, I prefer to include jerboas from El Gatrun within the subspecies *J. j. arenaceous*.

In the Fezzan, jerboas were obtained from a wide variety of habitats, ranging from practically barren hamadas to the bleak margins of sand seas. In these habitats, plants occur sparingly and are represented by relatively few species, one kind usually being dominant. In most instances, jerboas were not found in the oases proper but in the more open, outlying areas.

The name *arenaceous*, meaning of sand or sandy, refers to the sandy color of the pelage of these jerboas.

#### *Jaculus jaculus collinsi*, new subspecies

Holotype. Adult male, skin and skull, USNM 325797, from Tazerbo Oasis, Cyrenaica Province, Libya; obtained Apr. 15, 1962, by G. L. Ranck, original no. 2039.

Specimens examined. Twenty, from Cyrenaica: Gialo Oasis, 5; Bir el Harasc, 1; Bir bu Zarregh, 1; Tazerbo Oasis, 11; El Gezira, 2.

Measurements. The averages and extremes of five males and six females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 292 (282–307), 294.2 (275–313), [293]; length of tail 182.2 (175–192), 183.3 (166–197), [182]; length of hind foot 61.6 (61–63), 61 (58–63), [62]; length of ear from notch 22.2 (21–23), 21.7 (21–23), [23]; greatest length of skull 33.6 (32.5–34.5), 33.3 (32.3–34.3), [34.4]; condyloincisive length of skull 29.9 (28.6–30.9), 29.6 (28.7–34.3), [30.7]; crown length of upper molariform toothrow 5.2 (5–5.3), 5.2 (4.9–5.4), [5.3]; greatest breadth across zygomatic processes 22.2 (21.6–23.4), 21.8 (21.4–22.9), [21.7]; least interorbital breadth 12.2 (11.8–12.3), 12 (11.5–12.6), [12]; length

of nasals 12.2 (11.6–12.8), 12.3 (11.6–12.8), [12.6]; breadth of rostrum at level of antorbital foramina 5 (4.7–5.3), 5 (4.7–5.1), [5.1]; greatest breadth of braincase, 18.2 (17.6–18.6), 18 (17.5–18.4), [18.4]; greatest breadth across antorbital processes 22.7 (22.3–23.1), 22.5 (21.7–23.6), [23.1].

Diagnosis. Upperparts Light Ochraceous-Buff with suffusion of darker hairs on rump; all hairs of dorsum Plumbeous basally; rostral circumorbital, mystacial, subauricular, interorbital, and pectoral regions Pale Ochraceous-Salmon; pinna of ear sparsely haired and Clay Color; underparts, flanks, and dorsum of fore and hind feet white, grading to Light Buff in some specimens; lateral vibrissae long and white; median vibrissae smaller and darker; hind feet heavily furred ventrally and Pale Pinkish Buff; palmar surfaces of front feet naked; tail Pinkish Buff dorsally, Light Buff ventrally, with prominent bicolored terminal pinna, Warm Sepia proximally and white distally; encroachment of buffy areas of the sides onto dorsum imparting a decidedly pale aspect to all of the specimens. Skull: Triangular; size medium; molariform teeth medium; auditory bullae moderately inflated; infraorbital foramina large; braincase relatively flattened, rostrum heavy; zygomata convergent anteriorly; pterygoid fossae large and partially enclosed ventrally by the palatines; pterygoid processes long and attenuated; basisphenoids, alisphenoids, presphenoids, and orbitosphenoids markedly reduced and restricted to median plane; lachrymals appearing as a posterior process of the maxillary and situated dorsad of the winglike antorbital processes; lateral margins of basioccipital convergent anteriorly; jugular processes small; distinct foramen located on ventroanterior margin of condyloid process and anterior margin of angular process; coronoid process markedly reduced.

Comparisons. From the type and the type series of *Jaculus jaculus cufrensis*, specimens of *J. j. collinsi* differ in larger size of most cranial characters, being smaller only in the least interorbital breadth and of comparable size in the greatest breadth across antorbital processes. Members of this subspecies also have larger molariform teeth, heavier zygomata, narrower rostra, and less compact skulls. *Jaculus jaculus collinsi* is paler in color owing to encroachment of the buffy areas of the sides onto the dorsum, less suffusion of dark hairs on the flanks, and the general overall Light Ochraceous-Buff of the back.

*Jaculus jaculus collinsi* appears to be most closely related to *J. j. jaculus* but can be distinguished by longer molariform toothrow, less inflated auditory bullae, larger infraorbital foramina, heavier rostrum, and less vaulted braincase. In color, *J. j. collinsi* is markedly paler, has greater suffusion of white or cream-colored hairs on the dorsum of the tail, and has less admixture of dark hairs on sides and flanks.

*Jaculus jaculus collinsi* differs from the type and the type series of *J. j. whitchurchi* in larger body size, longer tail, longer ears, more variegated color of dorsum, paler flanks and lateral regions, smaller lachrymals, wider rostrum, less vaulted braincase, heavier zygomata, and generally larger cranial measurements.

For comparison with *Jaculus jaculus arenaceous*, see account of that subspecies.

Animals from Gialo are noticeably paler and smaller in size than those from the type locality which lies farther to the south, suggesting intergradation with *Jaculus jaculus whitchurchi*, whose geographic range is to the north. This similarity in color could best be interpreted as a response to the paler colored soils nearer the coast, inasmuch as extensive areas of sand and barren hamada occur between Agedabia and Gialo. It is doubtful if genetic exchange is of common occurrence across this barrier.

Some of the type series were obtained from a large concentration of sparsely vegetated dunes associated with date palms, and the remainder were taken from among large clay hummocks at some distance from the oasis proper. The latter area supported sparse growths of *Tamarix* and *Calligonum*.

The subspecific name *collinsi* is proposed in recognition of Alan C. Collins, who made possible the trip to the Tibesti Mountains during the early spring and summer of 1961.

#### *Jaculus jaculus cufrensis*, new subspecies

Holotype. Adult female, skin and skull, USNM 325785, from El Giof, Cufra Oasis, Cyrenaica Province, Libya; obtained Apr. 2, 1962, by G. L. Ranck, original no. 1898.

Specimens examined. Seventeen, from Cyrenaica: El Giof, Cufra Oasis, 15 (1 skull only); El Hauuari, Cufra Oasis, 2.

Measurements. The averages and extremes of five males and seven females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 279.8 (273–285), 282 (270–297), [290]; length of tail 172.8 (164–178), 174.9 (165–184), [180]; length of hind foot 63.6 (61–65), 61.4 (60–64), [60]; length of ear 21.2 (20–22), 21 (20–22), [20]; greatest length of skull 33.2 (33–33.6), 32.7 (32.2–33.5), [32.7]; condyloincisive length of skull 29.3 (28.8–29.8), 28.7 (27.8–29.7), [28.9]; crown length of upper molariform toothrow 5.1 (4.8–5.4), 4.9 (4.7–5.1), [5.1]; greatest breadth across zygomatic processes 21.8 (21.1–22.7), 21.8 (21–22.7), [22.7]; least interorbital breadth 12.4 (12.1–12.9), 12.2 (12–12.5), [12.3]; length of nasals 12.1 (11.8–12.5), 11.6 (11.2–11.9), [11.7]; breadth of rostrum at level of antorbital foramina 4.8 (4.6–5), 4.8 (4.4–5.4), [4.8]; greatest breadth of braincase 17.6 (17.2–18.1), 17.7 (17.4–18.2),

[17.8]; greatest breadth across antorbital processes 22.3 (22–23.5), 22.1 (21–22.8), [22.7].

Diagnosis. Upperparts Cinnamon-Buff, more uniform anteriorly and becoming darker posteriorly owing to a slight admixture of brownish-tipped hairs; entire underparts, postauricular regions, and flanks whitish, the latter with infusions of brownish hairs imparting a streaked appearance; cheeks, mystacial areas, circumorbital regions, and pectoral areas Pale Pinkish Buff; anterior margins of pinna of ear with row of Pinkish-Buff hairs; remainder of pinna sparsely haired and Clay Color; tail and hind feet Pale Pinkish Buff dorsally; hind feet heavily furred, frequently Ochraceous-Salmon resulting from artificial staining by the substratum; tail, dorsally, approximating color of back but becoming lighter, more Pinkish-Buff, posteriorly and terminating in a distinct tuft or pinna of Bister Brown proximally and white distally; brown portion of the pinna becoming indistinct ventrally; tail, ventrally, Light Pinkish Cinnamon becoming lighter distally. In some specimens, the pinnate tail is stained a deep Ochraceous-Orange owing to prolonged contact with the reddish-orange substratum. Skull: Small; molariform teeth relatively small; auditory bullae moderately inflated; rostrum moderately narrow; zygomata convergent anteriorly; malar bone expanded laterally forming a wing-like antorbital process; lachrymals distinct and appearing as posterior appendages of the maxillary; infraorbital foramina large; braincase moderately vaulted; upper and lower incisors relatively short and narrow; angular process of mandible with posterolaterally directed process and possessing a well-defined foramen on its anterior margin, coronoid process small and reduced to a secondary process.

Comparisons. From topotypes of *Jaculus jaculus jaculus*, *J. j. cufrensis* differs in markedly smaller cranial measurements and generally smaller body size. The auditory bullae are less inflated in *J. j. cufrensis*, and the skull appears less massive in all general aspects. In color, *J. j. cufrensis* is lighter and more uniform in dorsal coloration (Cinnamon-Buff as opposed to Tawny-Olive), has paler colored vibrissae, less suffusion of dark hairs on lateral body surface, flanks white or creamy as opposed to buffy or tan, and much less admixture of dark hairs on the dorsum.

When compared with *Jaculus jaculus butleri* Thomas from the Sudan, *J. j. cufrensis* is similar in greatest length of skull, condyloincisive length and least interorbital breadth but is significantly smaller in zygomatic breadth, length of nasals, size of infraorbital foramina and breadth of rostrum. *Jaculus jaculus cufrensis* has a slightly more vaulted skull, greater flaring of the nasals anteriorly and more ventrally inflated auditory bullae. In color, *J. j. cufrensis* differs from *J. j. butleri* in having less admixture of dark hairs on the

dorsum, lighter coloration of the dark portion of the pinna of the tail, and much lighter, more ochraceous color of the dorsum.

In smaller size of almost all cranial and external measurements, this subspecies is readily separable from *Jaculus jaculus arenaceous.*

For comparison with *Jaculus jaculus collinsi,* see account of that subspecies.

Remarks. Specimens were taken only from extensive areas of "hamada" or pebble desert supporting a scanty vegetative cover. While foraging at night, these jerboas seem to prefer the rather barren areas peripheral to the oases proper. The conspicuous absence of burrows in these areas suggests, however, that the animals actually dwell and construct burrows in the sandy areas nearer the oases.

The name *cufrensis* is proposed in reference to the oasis of Cufra in southern Cyrenaica.

***Jaculus jaculus tripolitanicus*, new subspecies**

Holotype. Adult male, skin and skull, USNM 325773, from 25 km N Gharian, Tripolitania Province, Libya; obtained Mar. 6, 1962, by G. L. Ranck, original no. 1725.

Specimens examined. Five, from Tripolitania: 25 km N Gharian, 4; 40 km ENE Nalut, 1.

Measurements. The measurements of an adult female, 325771, and the averages and extremes of three adult males, 325770, 325772, and 325773, from the type locality, with the measurements of the type in brackets, are, respectively: Total length 302, 298.3 (290–300), [300]; length of tail 193, 181.7 (174–184), [184]; length of hind foot 66, 66.3 (61–65), [61]; length of ear 23, 21.7 (21–22), [22]; greatest length of skull 36.4, 34.9 (34.9–34.9), [34.9]; condyloincisive length of skull 31.9, 30.4 (30.2–30.6), [30.2]; crown length of upper molariform toothrow 5.3, 5.5 (5.4–5.7), [5.7]; greatest breadth across zygomatic processes 22.5, 22.6 (21.4–24.1), [24.1]; least interorbital breadth 12.5, 12.6 (12.3–12.9), [12.6]; length of nasals 13.4, 12.4 (11.7–13), [12.5]; breadth of rostrum at level of antorbital foramina 5.2, 4.8 (4.7–4.8), [4.8]; greatest breadth of braincase 19.2, 18.7 (18.2–19.1), [18.9]; greatest breadth across antorbital processes 23.7, 23.1 (22–23.8), [23.8].

Diagnosis. Upperparts, subauricular region, and flanks Cinnamon-Buff with strong admixture of brown-tipped hairs, more concentrated on rump; lateral areas Pinkish Buff with suffusion of dark hairs; overall dorsal coloration a uniform blending of light and dark hairs; rostral, supra- and infraorbital, mystacial, and postauricular areas Pale Pinkish Buff; pinna of ear sparsely haired with fringe of buffy hairs along anteromedial margins and otherwise Clay Color basally and Tawny-Olive terminally; fore and hind feet white dorsally; fore-

feet naked ventrally with five distinct claws; hind feet large and heavily furred ventrally, Pinkish-Buff with three distinct claws; tail indistinctly bicolored Cinnamon-Buff dorsally and Pale Pinkish Buff ventrally; prominent terminal pinna transversely bicolored Bone Brown proximally and white distally; dark portion of pinna of tail becoming white ventrally. Skull: Large and massive; cheek teeth heavy; zygomata heavy; braincase flattened; auditory bullae moderately inflated and large; anterior palatine foramina short and wide; lachrymals large; foramen on anterior margin of angular process markedly enlarged.

Comparisons. *Jaculus jaculus tripolitanicus* differs from the type and type series of *Jaculus jaculus whitchurchi* in larger, more massive skull, relatively, as well as actually, larger, more inflated, auditory bullae, heavier zygomata, wider anterior palatine foramina, larger infraorbital foramina, markedly less inflated braincase, and larger cranial and external measurements. In color, *J. j. tripolitanicus* has a much stronger and more uniform suffusion of dark-tipped hairs on the dorsum, a greater admixture of brownish hairs on flanks, and a more sharply bicolored tail with a much darker anterior portion of the pinna.

Compared with the type and type series of *Jaculus jaculus arenaceous*, *J. j. tripolitanicus* is larger and more massive in almost all cranial measurements, has more inflated auditory bullae, markedly wider anterior palatine foramina, more divergent pterygoid processes, larger lachrymals, more robust zygomata, and larger, more oval foramina on anterior fossa of angular process of mandible. In color, *J. j. tripolitanicus* has less admixture of dark-tipped hairs on sides and dorsum, more suffusion of buffy hairs on flanks, a more prominently bicolored tail, and a darker anterior portion of the pinna.

From topotypical *Jaculus jaculus jaculus*, specimens from Gharian are larger in all cranial measurements and have larger more inflated auditory bullae, a larger foramen magnum, more divergent pterygoid processes, more robust zygomata, less vaulted braincases, larger lachrymals, and more widely flaring nasals. *Jaculus jaculus tripolitanicus* also differs from the nominate subspecies in paler dorsal coloration, owing to less admixture of dark-tipped hairs, greater suffusion of buffy hairs on sides and pectoral regions, and more uniformly colored vibrissae.

In their generally large overall size and massive skulls, members of this subspecies resemble representatives of *Jaculus jaculus sefrius* from western Algeria but differ in having significantly longer hind feet, much larger ears, and longer molariform toothrows. The similarities probably do not indicate close taxonomic relationship, however, because populations of *Jaculus jaculus centralis*, a subspecies

markedly smaller in size than either *J. j. tripolitanicus* or *J. j. sefrius*, are interposed between their ranges.

Remarks. *Jaculus jaculus tripolitanicus* is larger cranially and has larger hind feet than any other subspecies of *Jaculus jaculus* in Libya.

A single specimen from 40 kilometers east-northeast of Nalut, Tripolitania, differs from the type series of *J. j. tripolitanicus* in more uniform color of dorsum with more yellowish coat, less admixture of dark-tipped hairs, and slightly larger hind feet. Cranially, this specimen does not differ significantly from animals from Gharian and is accordingly referred to *J. j. tripolitanicus*.

This large subspecies is apparently confined to the more humid environments of the Gefara Plain north of the Gebel Nefusa.

Both the type series and the specimen from 40 kilometers east-northeast of Nalut were taken from localized concentrations of vegetated dunes near the escarpment of the coastal plain. Fresh burrows were abundant in the sand throughout the traplines, suggesting a high population density. *Gerbillus aureus* and *Meriones caudatus* were also collected from this same habitat.

The name *tripolitanicus* refers to the range ascribed to this subspecies in northern Tripolitania Province.

#### *Jaculus jaculus whitchurchi*, new subspecies

Holotype. Adult male, skin and skull, USNM 325807, from 10 km S Agedabia, Cyrenaica Province, Libya; obtained June 18, 1962, by G. L. Ranck, original no. 2362.

Specimens examined. Thirty-one, from Tripolitania: 12 km W Sirte, 3; 15 km WNW Marble Arch, 1; from Cyrenaica: 10 km S Agedabia, 17; Giarabub, 8; 24 km SSE Giarabub, 1; Bahr el Tubat, 21 km ESE Giarabub, 1.

Measurements. The averages and extremes of 12 males and 3 females from the type locality, with the measurements of the type in brackets, are, respectively: Total length 287.6 (280–296), 300.3 (294–305), [282]; length of tail 178.6 (174–182), 186.3 (184–190), [177]; length of hind foot, 62.3 (59–64), 62.7 (60–65), [62]; length of ear 21.4 (19–23), 21.7 (20–23), [21]; greatest length of skull 33.2 (31.8–34.5), 34.1 (33–34.8), [32.8]; condyloincisive length of skull 29.4 (28.5–30.4), 29.9 (29.3–31.1), [28.7]; crown length of upper molariform toothrow 5.1 (4.7–5.4), 5.2 (5–5.4), [5]; greatest breadth across zygomatic processes 21.7 (20–22.5), 23 (22.5–23.8), [21.9]; least interorbital breadth 12.4 (11.8–13), 12.6 (12.4–13), [12.4]; length of rostrum at level of antorbital foramina 4.8 (4.5–5.3), 4.8 (4.6–5), [4.8]; greatest breadth of braincase 18 (17.1–18.9), 17.8 (17.5–18.2), [17.1]; greatest breadth across antorbital processes 22.4 (21.3–23.8), 22.8 (22.6–23), [22.3].

Diagnosis. Upperparts Cinnamon-Buff becoming darker on rump owing to admixture of brownish hairs; rostral, mystacial, circumorbital, pectoral, and postauricular areas Light Buff; flanks and lateral areas with slight admixture of brownish hairs; entire underparts, dorsum of front and hind feet and terminal portion of tail white; pinna of ear sparsely furred and Clay Color; hind feet, ventrally, heavily furred and frequently stained Pale Orange-Yellow; tail indistinctly bicolored, Pale Yellow-Orange dorsally and Light Buff ventrally; pinnate tail sharply demarcated into a Bister anterior portion and white posterior portion. Skull: Small; triangular in shape; braincase prominently vaulted; zygomata convergent anteriorly; auditory bullae moderately inflated; lachrymals relatively large; rostrum narrow; zygomata relatively fragile; foramen on anterior margin of angular process enlarged longitudinally; coronoid process markedly reduced.

Comparisons. When compared with topotypes of *Jaculus jaculus jaculus*, *J. j. whitchurchi* differs in smaller body size, shorter tail, shorter hind foot, markedly shorter ears, and generally smaller size of cranium. Specimens of *J. j. whitchurchi* are paler and more uniformly colored dorsally and have less suffusion of brown on the sides and flanks.

For comparisons with *J. j. tripolitanicus*, *J. j. collinsi*, and *J. j. arenaceous*, see accounts of those subspecies.

Remarks. This new subspecies of jerboa is largely restricted to the Libyan littoral desert along the Gulf of Sirte. Specimens from Giarabub, however, are referable to this subspecies and occur more than 200 kilometers from the coast. Apparently, the vast hamada north and east of the Sand Sea of Calanscio provides suitable habitat for jerboas and allows for gene flow between these coastal and interior populations. North and east of the Gulf of Sirte, dispersal is rendered impossible by the escarpments of the Cyrenaican Plateau and Gebel el Achdar. Widespread areas of sand between Gialo Oasis and the coast also preclude interbreeding between *J. j. whitchurchi* and *J. j. collinsi*.

The type series was obtained from a complex of heavily vegetated coastal dunes about one-half kilometer from the Mediterranean coast. Specimens from Sirte and Marble Arch were collected from the alkaline-clay soils of the coastal plain and farther removed from water.

A specimen, 325802, from Giarabub, Cyrenaica, is markedly paler and more uniformly colored dorsally than any other jerboa examined from Libya. This particular specimen is an old female and probably represents an extreme color variation incident to age.

*J. j. whitchurchi* is proposed in recognition of Lt. Colonel Thomas Whitchurch, former Commanding Officer of the 64th Engineering

Battalion, Wheelus Air Force Base, Tripoli, who provided support essential to the field work in Libya.

### *Jaculus orientalis orientalis* Erxleben

*Jaculus orientalis* Erxleben, Syst. Regni Animalis, p. 404, 1777 (Egypt, in the mountains separating Egypt from Arabia).

General distribution of species. Egypt (including Sinai), Libya, Algeria, Tunisia, and Morocco.

Distribution in Libya. Coastal areas of Cyrenaica and Tripolitania and inland to Augila (Gialo Oasis).

Specimens examined. Twenty-five, from Cyrenaica: 12 km NW Gubba, 1; 5 km NW Labrag, 1; 2 km W Tocra, 1 (skull only); 2 km N Coefia, 2; 8 km N Benghazi, 1; Gheminez, 18 (1 skin only; 1 skeleton); from Tripolitania: 20 km E Rumia, 1.

Published records in Libya. Cyrenaica: Sidi Faradie (Thomas, 1902); Gheminez (Festa, 1921) Mechili (Festa, 1925); Agedabia, El Agheila, Augila (de Beaux, 1932); Zauia Mechili (de Beaux, 1938); Tripolitania: Tripoli (Klaptocz, 1909); Tripolitania (Toschi, 1951).

Measurements. The averages and extremes of 14 adult males and 4 adult females from Gheminez, Cyrenaica Province, and the measure-

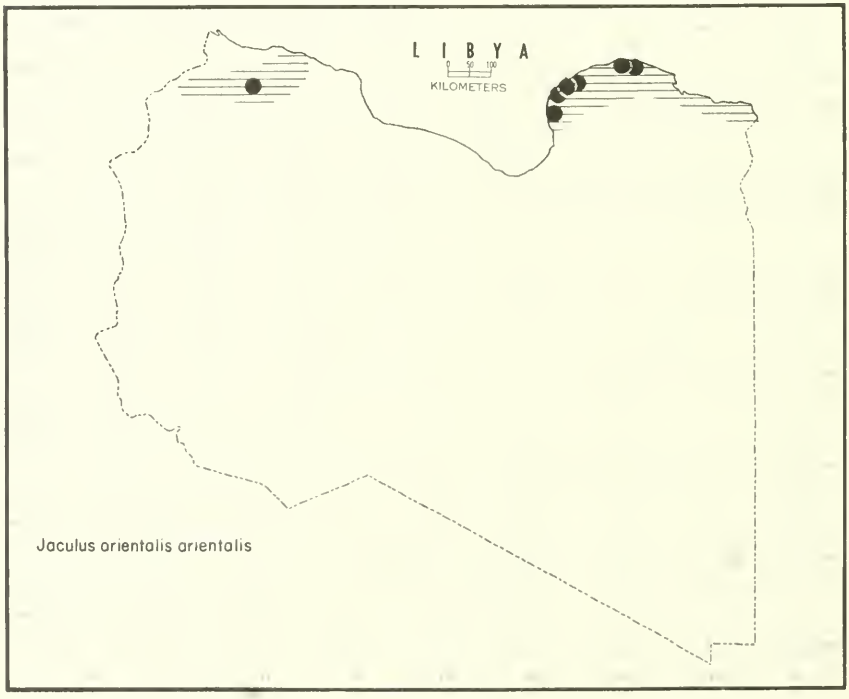


Figure 51.—Distribution of *Jaculus orientalis orientalis*.

ments of an adult male, 325835, from 20 kilometers east of Rumia, Tripolitania Province, are, respectively; Total length 370.7 (354–382), 361 (354–372), 362; length of tail 222.1 (204–230), 215.5 (214–217), 210; length of hind foot 76.5 (75–78), 73.5 (71–76) 79; length of ear from notch 32.8 (30–36), 31.5 (30–35) 30; greatest length of skull 38.4 (36.6–39.4), 37.9 (37.2–39.2), 38.1; condyloincisive length of skull 35 (33.7–36.1), 34.8 (34.6–35.1), 35.1; crown length of upper molariform toothrow 5.9 (5.5–6.1), 6.1 (6.1–6.2), 6.5; least interorbital breadth 14.1 (13.6–15.1), 14.2 (13.8–14.6), 14.4; length of nasals 14.8 (13.9–15.6), 13.8 (13.6–14.2), 14.5; breadth of rostrum at level of antorbital foramina 5.8 (5.4–6.4), 5.5 (5.2–5.9), 6.3; greatest breadth of braincase 20.4 (19.4–21.2), 20.4 (19.8–21.1), 20.8; greatest breadth across antorbital processes 27.7 (25.4–29.1), 27.5 (27.2–28), 28.1.

Diagnosis. Upperparts and flanks Clay Color with strong suffusion of dark hairs resulting in a streaked or marbled appearance; this effect more prominent on rump; sides, ventrolateral and scapular areas Pinkish Buff with strong admixture of brownish-black hairs; underparts and forearms white but suffused with Pale Pinkish Buff; subauricular, postauricular, and postorbital areas Cinnamon-Buff grading to Pale Pinkish Buff in circumorbital and mystacial areas; all areas, except those which are white, with strong admixture of black hairs; pinnae of ears sparsely haired and Sepia on internal and lateral aspects, Tawny Olive on medial margin; vibrissae long, proximally dark in color (Fuscous) and white distally; forelegs and hindlegs sparsely haired and whitish dorsally; fore feet naked ventrally and bearing five claws; hind feet bearing three claws, heavily furred ventrally with dark hairs (Clove Brown) concentrated on sole and extending along ventral surface of metatarsus; digital areas Pale Pinkish Buff; tail indistinctly bicolored Clay Color dorsally and Light Buff ventrally with terminal pinna, transversely bicolored, Fuscous Black proximally and white distally. Skull: Large and robust; braincase slightly vaulted; molariform teeth large; zygomata heavy and bearing large, winglike antorbital processes; auditory bullae moderately large; anterior palatine foramina expanded posteriorly and laterally; nasals flaring anteriorly; rostrum relatively wide and heavy; angular process of mandible with large, single oval foramen on its anterolateral surface.

Comparisons. From *Jaculus orientalis orientalis*, as known from Mersa Matruh, Western Desert Governorate, Egypt, the series from Gheminez differs in having slightly larger size of most external and cranial measurements but in being smaller or of comparable size in length of ears and breadth of rostrum at level of antorbital foramina. Jerboas from Gheminez also have slightly larger lachrymals, and the anterior palatine foramina are less expanded posteriorly. The two

populations agree closely in color, but specimens from Gheminez have slightly less admixture of dark hairs on the rump.

Compared to a near topotype (BM, no. 12.6.12.170), of *Jaculus orientalis mauritanicus* Duvernoy from Guelt es Stel, Central Plateau, Algeria, and a specimen (BM, no. 25.6.3.8) representing *J. o. mauritanicus* from near Sfax, Tunisia, the Libyan specimens are more uniformly colored dorsally, have less suffusion of Ochraceous-Salmon on the sides and flanks, are somewhat smaller in total length and length of tail, have narrower and longer rostra, and are slightly smaller in the length of skull.

*Jaculus orientalis*, in Egypt and Libya, although resembling *Jaculus blanfordi* (Murray) in some superficial characters, differs markedly in all of the salient features. Specimens of the latter species as known from Majan (50°02′ E, 32°35′ N), Dasht-i-lut, and near Jangal, Khurasan Province, Iran, differ from those of *J. orientalis* from Gheminez in smaller size of every cranial and external measurement. *Jaculus blanfordi* also differs from *J. orientalis* in darker, more uniform dorsal color, more distinctly bicolored tail, less buffy sides more heavily washed with gray, smaller terminal spines on baculum, darker vibrissae, whiter underparts (as opposed to Pale Pinkish Buff), proportionately larger front feet and claws, and darker, almost black, proximal portion of pinna of tail. Cranially, *J. blanfordi* has a more flattened skull, proportionately more fragile zygomata, smaller molariform teeth, relatively larger and more inflated auditory bullae, and two, rather than one, distinct, oval foramina in the angular process of the mandible.

Remarks. An adult male, 325835, from 20 kilometers east of Rumia, Tripolitania Province, differs significantly from the series from Mersa Matruh and other specimens from Libya, in that it is much darker dorsally with markedly stronger admixture of dark hairs, resulting in a streaked or marbled appearance. The sides and pectoral areas are more heavily suffused with Ochraceous-Salmon. Cranially, this specimen from Tripolitania differs from typical *Jaculus orientalis orientalis* in having a wider rostrum, smaller lachrymals, narrower anterior palatine foramina, larger foramen in angular process, longer cheek teeth with more laterally directed occlusal surfaces, and lateral margins of antorbital processes more abruptly curved.

In the above characters, this specimen from near Rumia shows intergradation with *Jaculus orientalis mauritanicus*, whose range includes northern Algeria and Morocco. No topotypical specimens of the latter subspecies are available for study, but Loche (1867, pp. 98–99) gives the following description: "The jerboa of Mauritanica is very large, very powerful and darker in color (more russet) than the jerboas of Tripoli. The underparts, the throat, and the extremities

are light yellow or russet, and the dorsum is more streaked or marbled. The tail is brownish rust above with some blackish hairs at the tip (6 or 7 cm)." *Jaculus o. mauritanicus* apparently also has a shorter, wider muzzle, a larger head, smaller ears in proportion to the body, and generally a larger, more robust body. The jerboa from Rumia shows some of these characters, particularly in width or rostrum, streaked and darker dorsum and proportionately smaller ears, but in general body size and in most cranial characters, it is closer to the nominate subspecies and is here so referred. The referral of this specimen from Tripolitania to *J. o. orientalis* is, however, provisional until such time as adequate series of these large jerboas become available from western Libya and permit a more thorough study.

The type locality of *J. o. orientalis* is not firmly fixed but is believed to be somewhere in the mountains separating Egypt from Arabia and thus probably near Sinai. Only one subadult specimen is available from Sinai, however, and thus valid comparisons with jerboas from Libya are not possible. It is doubtful if the large jerboas inhabiting the coastal areas of Sinai, Egypt, and Libya are all of the same subspecies. Setzer (1957) also questioned the occurrence of a single subspecies over such a wide geographical area.

Local differences in pelage color of these large jerboas are noticeable throughout their range in Cyrenaica. These differences are probably attributable to differences in age, sex, or seasonal change. Much larger series are required to determine the exact taxonomic significance of color in these large jerboas.

Ecological observations. In Libya, these large jerboas are confined almost exclusively to the more humid environment of the coastal plain. Occasionally, specimens were taken from hamadas farther inland, and on one occasion, in Tripolitania, one was collected from the brink of the coastal escarpment. This species was recorded by de Beaux (1932) from Augila, Cyrenaica Province, at a distance somewhat removed from the coastal plain. The elevation at Augila, however, is relatively low and accordingly the general habitat here is similar to that of the coastal plain.

These jerboas are difficult to catch by standard trapping procedures and trap yields are usually low. Setzer (1957) was able to obtain the series from Gheminez only by digging the animals from their burrows. At this time, he also obtained several specimens of the four-toed jerboa (*Allactaga tetradactyla*).

On two occasions, adult specimens were picked up some distance from a trapline. Apparently, these animals had been struck on the head by a trap but were able to move some distance before dying. Museum special traps are not of sufficient size to immediately kill and hold animals of this size.

On several occasions these jerboas were observed hopping about the dense vegetation of the Cyrenaican coastal plain near Tobruch shortly before dusk. They appear to be most active immediately following dusk.

## Genus *Allactaga* Cuvier

### *Allactaga tetradactyla* (Lichtenstein)

*Dipus tetradactylus* Lichtenstein, Verz. Doubl. Mus. Berlin, p. 2, 1823 (near Alexandria, Egypt).

General distribution of species. Coastal hamadas of Egypt and eastern Libya. In Egypt, this species is known from the type locality, Mersa Matruh, Burg el Arab, Bahig, Sidi Barrani, and Mariut (El Amiriya).

Distribution in Libya. Known only from Gheminez, El Agheila, and Zauia Mechili.

Specimens examined. Three, all from Gheminez, Cyrenaica Province.

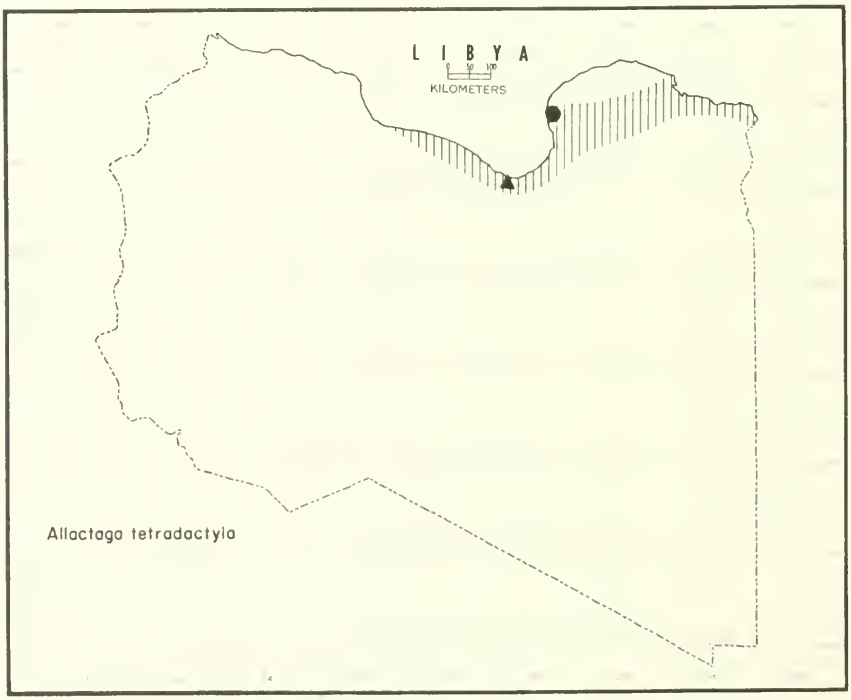


Figure 52.—Distribution of *Allactaga tetradactyla*. Circle indicates specimens examined; triangle indicates published record.

PUBLISHED RECORDS IN LIBYA. CYRENAICA: Mechili (Festa, 1925); El Agheila (de Beaux, 1932); Zauia Mechili (de Beaux, 1938).

MEASUREMENTS. The measurements of two adult males, 302294 and 302295, and an adult female, 302293, from the above locality, are, respectively: Total length ?, 295, 293, length of tail ?, 179, 176; length of hind foot 57, 59, 58; length of ear 42, 44, 43; greatest length of skull 32, 32.3, 31.6; condyloincisive length of skull 29.4, 29.9, 29.1; crown length of upper molariform toothrow 5.9, 6, 5.9; greatest breadth across anterior zygomatic processes 22.2, 22.5, 21.5; least interorbital breadth 9.8, 9.8, 10.2; length of nasals 11.4, ?, 11.1; breadth of rostrum at level of antorbital foramina 5.5, 5.6, 5.7; greatest breadth of braincase 18.9, 19, 18.9.

DIAGNOSIS. Dorsum generally dark (Drab) becoming lighter (Cinnamon) on rump; entire dorsum strongly suffused with grayish hairs and appearing uniformly variegated, the latter becoming more pronounced on sides owing to a blending of white and blackish hairs; flanks, preauricular, subauricular, and pectoral areas Cinnamon-Buff; distinct Light Buff patch between eye and base of ear; mystacial, suborbital, and circumoral areas Pale Ochraceous-Salmon; vibrissae relatively short and uniformly colored Mummy Brown; ears very large; base of pinna Pinkish Cinnamon grading to Drab on sparsely haired distal and medial portion; internal face of pinna lacking hair and Dark Olive; forefeet sparsely haired and white dorsally, heavily furred ventrally with sole and metatarsal area Bister and bearing three primary digits with claws and one rudimentary digit and claw applied to metatarsus; tail Sayal Brown dorsally, becoming slightly lighter ventrally and with terminal pinna, transversely bicolored dark brown proximally and white distally; entire underparts white. Skull: Small and compact; braincase, particularly the parietals, markedly inflated, sloping markedly anteriorly from coronal suture to front margins of nasals; medial portions of frontals forming a distinct depression in median line; squamous portion of temporal projecting markedly laterad thus rendering a "bowed" appearance to zygomata; zygomata relatively fragile and markedly convergent anteriorly; antorbital processes reduced; lachrymals relatively large; infraorbital foramina relatively large; rostrum wide; upper incisors small and short; upper molars large and directed laterad; small rudimentary premolar applied to anterior surface of first upper molar; anterior palatine foramina large and markedly expanded posteriorly; pterygoid hamulae heavy and knobbed; posterior palatine canal large and elongated; palate heavy, with distinct spine directed caudad; auditory bullae markedly small and but little inflated; basioccipital wide, occiptal condyles and jugular processes large; mandible large and bearing a deep fossa on

ventral margin of coronoid process; angular process reduced and with a single trianguliform foramen on anteroventral margin; molariform teeth large, lower incisors thin and attenuated.

Comparisons. Specimens from Gheminez are slightly larger cranially and in external body measurements than specimens from Burg el Arab, Western Desert Governorate, Egypt. In color, animals from Libya are more uniform and less streaked dorsally, have more darkly colored soles of the hind feet and metatarsal areas, have a more prominent buffy patch above the eye, and are less suffused with buff on the sides and pectoral areas.

Remarks. The above differences are of insufficient magnitude to be of taxonomic significance and probably fall within the range of variation for the species. In view of the wide geographic range of *Allactaga tetradactyla*, it has undergone comparatively little local differentiation. Setzer (1958) referred to this genetic stability and was also unable to demonstrate significant variation either between or within populations of this kind of jerboa. Apparently, suitable habitat occurs uninterruptedly throughout its range and, as a consequence, there has been little interruption of gene flow. When adequate series of *A. tetradactyla* become available, however, some variation undoubtedly will be demonstrable, and this species will prove to be polytypic.

Ellerman and Morrison-Scott (1951) did not include Libya within the range of *A. tetradactyla*. Apparently, they were unaware of the collections reported by Festa (1925) and de Beaux (1932) from Zauia Mechili and El Agheila. The present study contributes but little to the knowledge of the distribution of this kind of jerboa. The few collecting localities in Cyrenaica do suggest a limited occurrence in Libya but probably do not provide an accurate distributional picture. As with most uncommon species, the few collecting sites indicate a fortuitous meeting of collector and animal and do not render an accurate estimate of the population size.

Ecological observations. The four-toed jerboa inhabits the hamadas of the Mediterranean littoral. These coastal deserts are relatively free of sand and are composed of boulder-strewn plains where vegetation grows sparingly or is frequently wanting. These jerboas apparently dislike habitats of a sandy character and accordingly are unknown from the Saharan interior. The collecting locality at Zauia Mechili is still well within the zone of coastal hamadas and has no real relationship to the Sahara proper.

Setzer (1957) obtained the small series from Gheminez by digging the animals from their burrows but was unable to obtain specimens by trapping. Collecting efforts by the author were to no avail.

## Family Hystricidae

### Genus *Hystrix* Linnaeus

#### *Hystrix cristata* Linnaeus

*Hystrix cristata* Linnaeus, Syst. Nat. 10th ed., vol. 1, p. 56, 1758 (near Rome, Italy).

Remarks. I have not examined any Libyan specimens of the porcupine, and judging from the few records available in the literature, they occur only sparingly in the mountainous areas near the coast. They are apparently unknown from the deserts and oases of the interior.

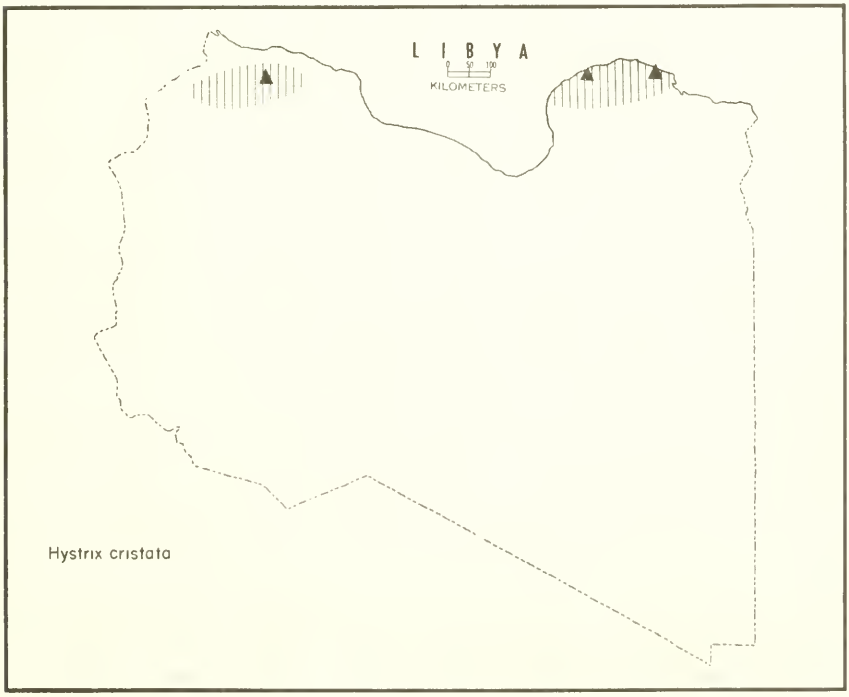


Figure 53.—Known localities of occurrence of *Hystrix cristata.*

While we were camped in the Gebel es Soda of southern Tripolitania, a local bedouin mentioned having frequently seen porcupines in the surrounding mountains, but I observed no signs of their presence here or elsewhere in Libya. Setzer (1957) found spines of the porcupine at Wadi Ahmar, 40 kilometers southeast of Benghazi, in Cyrenaica, but obtained no specimens.

Records of porcupines from Gharian (Klaptocz, 1909) and Barce (Festa, 1921) indicate that they occur on the Cyrenaican Plateau, as well as the Tripolitanian Gebel, and probably are commonest in these mountainous regions of Libya. The broad, chaparral-covered valleys of the Cyrenaican Plateau and the rocky canyons of the coastal escarpment in Cyrenaica and Tripolitania probably provide the most suitable habitats for porcupines. A specimen from Derna in northern Cyrenaica (de Beaux, 1938) constitutes the only known record from the coastal plain proper, but the coastal escarpment near Derna approaches near to the sea, almost obliterating the coastal plain, and probably this specimen was taken from the escarpment rather than from the coastal plain.

## Family Ctenodactylidae

### Genus *Ctenodactylus* Gray

#### *Ctenodactylus gundi* (Rothman)

*Mus gundi* Rothman, Schloezer's Briefwechsel, p. 339, 1776 (Gharian, 80 km S Tripoli, Libya).

General distribution of the species. Libya, Tunisia, Algeria, and Morocco.

Distribution in Libya. Mountainous areas and the larger wadis of northern Tripolitania.

Distribution of the subspecies in Libya.

*Ctenodactylus gundi gundi.* Tripolitania: The Gebel Nefusa, Gebel Tigrinna, Gebel Jefren, and other parts of the Tripolitanian Gebel.

*Ctenodactylus gundi vali.* Tripolitania: The transitional desert between the Gebel es Soda and the Gulf of Sirte.

Published records in Libya. Tripolitania: Gharian (Yarrel, 1831; Klaptocz, 1909; Toschi, 1951); Wadi Titti, Bu Ngem (Thomas, 1902); Wadi Soffegin at Orfella (Toschi, 1951).

Remarks. In the past, the gundis of Libya have been variously regarded as two distinct species, *Ctenodactylus gundi* and *Ctenodactylus vali* (Thomas, 1902; Klaptocz, 1909; Zavattari, 1934; Toschi, 1951; Petter, 1961), or considered as one species, *C. gundi*, with *C. vali* treated as a subspecies (Ellerman and Morrison-Scott, 1951; Toschi, 1954; Setzer, 1957).

Petter (1961) regarded *C. vali* and *C. gundi* as separate species but used sympatry as his primary argument in establishing their specific identity. He apparently misinterpreted Toschi (1951) and presumed that the collecting site of *C. vali* in the Wadi Soffegin and the collecting sites of *C. gundi* on the Gebel Nefusa were part of the same plateau complex. Actually, the ranges of *C. vali* and *C. gundi* are geographi-

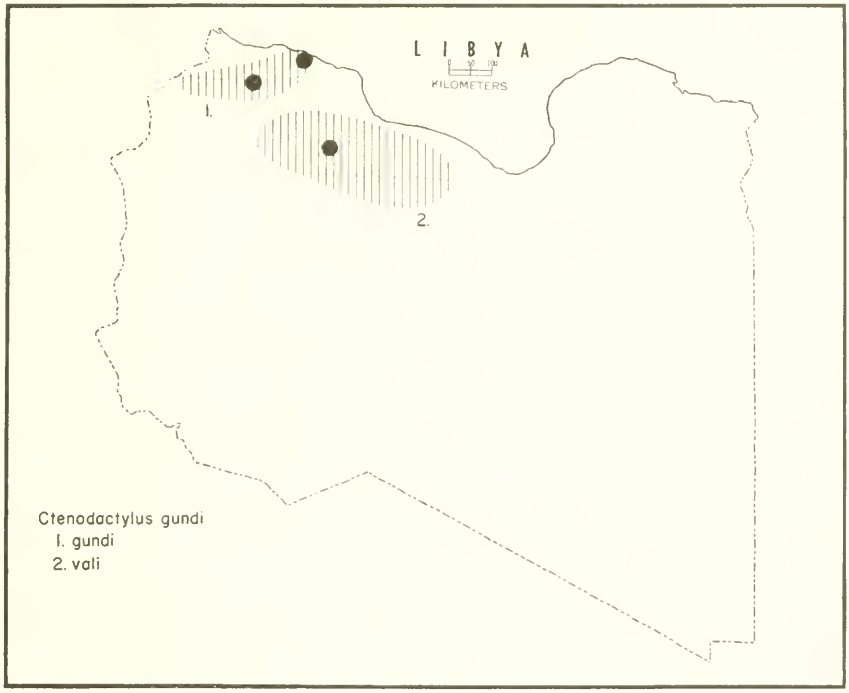


FIGURE 54.—Distribution of the subspecies of *Ctenodactylus gundi*.

cally, physiographically, and climatically distinct and, to my knowledge, there are no records of these two forms occurring together.

I am in agreement with most recent workers in regarding *C. vali* as a subspecies of *C. gundi*. The single topotype of *C. vali* available to me is significantly different morphologically from near topotypes of *C. gundi* from northwestern Tripolitania, but these differences, in my opinion, are only of subspecific worth (for detailed comparisons of *C. g. gundi* and *C. g. vali*, see following account of *C. g. gundi*). Currently, and in the past, however, too few specimens of *C. vali* have been available and preclude any unequivocal conclusions concerning the systematic position of this form. For the present, therefore, it seems best to regard *C. g. vali* as a subspecies of *C. gundi*, rather than as a distinct species. When adequate series of *C. g. vali* become available for a more critical analysis of this form, it may prove to be a separate species.

Judging from my observations of the *gundi* (*Ctenodactylus gundi*) in Libya, and those of several other collectors in the past, they are confined exclusively to rocky outcroppings and boulder fields of the Gebel Tigrinna, Gebel Jefren, and Gebel Nefusa of northwestern Tripolitania and to the irregular rocky scarps along the larger wadis,

such as the Wadi Bey, Wadi Soffegin, and Wadi Titti located farther to the southeast.

***Ctenodactylus gundi gundi* (Rothman)**

*Mus gundi* Rothman, Schloezer's Briefwechsel, p. 339, 1776 (Gharian, 80 km S Tripoli, Libya).

Specimens examined. Twenty-nine, from Tripolitania: 5 km W Cussabat, 24 (1 skeleton); 20 km E Rumia, 5.

Measurements. Averages and extremes of five adult males and seven adult females from 5 kilometers west of Cussabat, are, respectively: Total length 221.4 (200–240), 232 (220–245); length of tail 22.8 (20–25), 24.3 (20–30); length of hind foot 40.6 (38–44), 37.6 (35–44); length of ear 18.8 (18–20), 19.3 (18–20); greatest length of skull 48.3 (47–49.3), 48.3 (46.4–51.4); basilar length of skull 36.8 (35.4–38.1), 37.7 (36.5–39.7); greatest breadth across zygomatic arches 32.2 (30.7–33.4), 31.8 (30.3–33.2); length of nasals 19.4 (18.4–20.7), 20.3 (18.5–21.6); greatest breadth of nasals 6.2 (5.8–6.5), 6.5 (6.4–6.7); least interorbital breadth 12.1 (11.8–12.6), 12.3 (11.5–12.6); breadth of interparietal 12 (11.4–12.6), 11.7 (11.4–12.3); length of diastema 12 (11.3–12.5), 12.1 (11.6–12.8); length of anterior palatine foramina 7.8 (7.4–8.2), 8 (7.7–8.4); crown length of upper molariform toothrow 9.5 (8.4–9.9), 9.7 (9.4–10.2); oblique length of auditory bulla 16.8 (16–17.6), 16.9 (16.2–17.5); height of auditory bullae 14.4 (13.7–15.3), 14 (13.6–14.5); jugular breadth 19.5 (18.8–20.6), 19.2 (18.1–20).

Diagnosis. Entire pelage silky and lustrous, Cinnamon-Buff dorsally with moderate suffusion of brown on middorsal and facial regions, and Pinkish Buff ventrally with frequent exposure of the Plumbeous underfur; long brown guard hairs of the dorsum extending noticeably beyond level of underlying pelage; circumoral area and chin slightly paler than surrounding pelage and approaching Light Ochraceous-Buff; dorsal surfaces of fore and hind feet Light Buff with mild suffusion of Warm Buff; ventral surfaces of fore and hind feet black and naked, with prominent metacarpal and metatarsal tubercles, and with thickened pads at the bases of the short black claws; each appendage with four functional digits; each digit of the hind foot enveloped terminally by stiff, bristle-like hairs, some of which are markedly hardened and resemble claws; vibrissae long, black, and extending posteriorly beyond level of the ears; pinna of ear small and inconspicuous, round in shape and with black inner surface; outer rim of pinna approaching Light Buff and contrasting markedly with the darker color of the surrounding pelage; tail markedly short and uniformly colored Warm Buff. Skull: Large, massive, and extremely angular with heavy parietal ridges and zygomata; nasals wide and slightly flaring anteriorly; lachrymals and dor-

sal portion of the jugals greatly expanded, forming a large portion of the wide antorbital plate; maxillary component of the antorbital plate narrow, owing to the extremely large size of the infraorbital foramen; parietal ridge terminating in a conspicuous flattened protuberance on posterior margin of the orbit; interparietal large and broadly elliptical; auditory bullae heavily ossified and irregular in shape; audital portion of bulla mildly inflated and meatal process heavy and projecting conspicuously laterad; mastoidal portion of bulla moderately inflated and extending posterior to occiput; portion of bulla above meatus expanded into a rounded prominence between the mastoidal portion of the bulla and the squamous portion of the temporal bone; jugular processes large with distal portions directed anteromedially; basioccipital broadly wedge-shaped and with faint median rib; pterygoid processes rounded on medial aspect and hamulae applied to the styliform processes of the auditory bullae; basisphenoid present as a distinct rod-shaped structure between the pterygoid processes, which become progressively narrower anteriorly; pterygoid fossae large, partially enclosed ventrally by the palatine bones, and with large foramina on their posterolateral portions; mandibular fossae large and deeply grooved; upper molariform teeth with shallow kidney-shaped crowns; anterior palatine foramina extremely large and bowed laterally; upper incisors relatively small, with a decided notch distally and with plain outer faces; mandible coarse and angular and with a distinct medial curvature; lower molariform teeth kidney-shaped and with conspicuous styles on medial surfaces; coronoid process reduced to a slight elevation of the ramus; angular process small and attenuated; lower incisors small and distinctly chisel-shaped.

Comparisons. Specimens representing *Ctenodactylus gundi gundi* from near Rumia and Cussabat on the Gebel Nefusa, northwestern Tripolitania, differ strikingly from a single topotype of *Ctenodactylus gundi vali* from the Wadi Bey, northwest of Bu Ngem, Tripolitania, in having smaller and less inflated mastoidal portions of the auditory bullae, narrower rostra, larger and wider infraorbital foramina, wider interorbital breadths, and heavier angular process of the mandible. The skull of the specimen from Bu Ngem is badly broken, and, consequently, most cranial measurements could not be taken. By inference, however, *C. g. gundi* would seem to be slightly larger in most all of the standard cranial measurements. Thomas (1902), in the original description of *Ctenodactylus vali*, gives the following characters by which *vali* differs from *C. g. gundi:* Auditory bullae larger; nasals longer and narrower; antorbital projections more delicate; interparietal narrower, molars smaller and more delicate (shorter anteroposteriorly), and the last molar less distinctly L-shaped than in *C. g. gundi*. In external dimensions, representatives of *C. g. gundi*

from northwestern Tripolitania are generally larger than the specimen of *C. g. vali* from the Wadi Bey, the two forms being closest in the length of the hind foot and ear. Except for total length, the external measurements of the type specimen of *C. g. vali*, as given by Thomas, are also significantly smaller. In *Ctenodactylus gundi vali*, the pelage is longer, silkier, slightly paler in color, and more evenly suffused with brown hairs. The venter is paler than in *C. g. gundi* and has less suffusion of buff or tan. The pinna of the ear in *C. g. vali* is brown on its inner surface rather than black as in *C. g. gundi*, has a thicker covering of hair, a more prominent tuft of buffy hairs on the anterior margin, and the color of the hair on its outer surface is similar to that of the dorsum and not markedly contrasting in color, as in *C. g. gundi*.

A specimen, 122110 (sex unknown), from Gafsa, Tunisia, agrees rather closely in cranial features and measurements with those of *C. g. gundi* from Tripolitania but is noticeably wider in interorbital breadth. External measurements of this Tunisian specimen are not available, but judging from the relative size of the prepared skin, it appears to be comparable in size to typical *C. g. gundi* from Libya. In color, it is somewhat darker dorsally, paler ventrally, and has more admixture of yellow on the dorsal surfaces of the feet. These few differences are not sufficient for separation at even the subspecific level, and this specimen is here referred to *C. g. gundi*.

Remarks. The five specimens from the Gebel Nefusa, 20 kilometers east of Rumia, Tripolitania, are near topotypes of *Ctenodactylus gundi gundi*, and in addition to the large series of gundis from 5 kilometers west of Cussabat, Tripolitania, represent the first records of this subspecies in northwestern Tripolitania since those reported from the type locality (Klaptocz, 1909).

The large series of gundis from near Cussabat probably contains the greatest number of specimens (24) ever collected from a single locality in Libya and in number probably exceeds all those previously collected in Libya.

While I was at Sebha Oasis in the Fezzan in 1962, an engineer employed by U.S.O.M. (United States Overseas Mission) mentioned having seen, earlier that year, "wild guinea pigs" in the rocky outcroppings near the village of Cussabat in northern Tripolitania. His description of them, although quite fragmentary and incomplete, suggested characters of the gundi, particularly as guinea pigs were not known to occur in Libya, at least not in the wild state. This brief discussion at Sebha prompted me, later that year, to search the vicinity of Cussabat and led eventually to the discovery of this large population of gundis.

The collecting site on the Gebel near Cussabat is located approximately 110 kilometers northeast of the type locality of *C. g. gundi* at Gharian and 135 kilometers northeast of the collecting locality near Rumia and is part of the same escarpment which sharply delineates the inner margin of the Tripolitanian coastal plain. The escarpment at Cussabat is neither as extensive nor as high as the gebel at Gharian and Rumia, but the character of the rocky outcroppings and coarse talus are similar in the two areas. Gundis from Cussabat and those from Rumia differ more than would be expected, however, in view of the similarity in terrain, the ecological continuity of the escarpment, and the relatively short distance separating them.

Specimens from Cussabat and Rumia are almost indistinguishable in the general shape and configuration of the skull, and both clearly represent *C. g. gundi*. In cranial and external measurements, however, those from near Cussabat are slightly larger in total length and length of ears, least interorbital breadth, and length of anterior palatine foramina. They are slightly smaller in length of tail and hind foot, width of interparietal, height of auditory bullae, and jugular breadth. In specimens from Cussabat, the angular process of the mandible is heavier (less attenuated), the pelage is more worn, shorter, thinner, less fluffy and silky and has less suffusion of brown hairs in the middorsal region. Ventrally, they are less buffy, being grayish rather than tawny, and have darker tails distally. The specimens from near Rumia were obtained in early March and presumably were in winter pelage, and those from Cussabat were taken in late June and consequently were in summer pelage. The differences in color and luster of the fur between specimens from these two areas may thus reflect seasonal characteristics of the pelage and may not indicate actual differences.

This subspecies attains its easternmost limits of distribution in northwestern Libya where it is known from only the vicinity of the type locality on the Gebel Nefusa and from near Cussabat. Its range, however, doubtless includes all of the coastal gebel as far east as the western margins of the Gulf of Sirte, south of which this subspecies probably intergrades with *C. g. vali*. The western limits of its range are unknown, but this subspecies probably occurs widely throughout the mountains and escarpments of Tunisia and the eastern portions of the Atlas Mountains in Algeria. Gundis are unknown from the Hamada el Hamra and the Hamada de Tinrhert of the Tripolitanian interior. Apparently suitable habitat does not occur in Libya this far inland.

Ecological observations. Near Rumia, gundis were occupying fissures and interstices of large rocks which together form the face

of the coastal escarpment. All specimens were collected near the brink of this escarpment where it becomes less abrupt and transforms into the high rolling uplands of the Gebel Nefusa. The coastal escarpment is varied in its degree of steepness and surface configuration. Frequently well-defined terraces exist on its slopes, into which have accumulated irregular masses of boulders and smaller rocks, all of which provide suitable habitat for the gundi. The less precipitous slopes of the larger wadis, which dissect the Gebel Nefusa and descend through the coastal escarpment onto the coastal lowlands, have irregular cliffs, rocky outcrops and boulder-strewn areas, which are ideal for the habitat requirements of the gundi. The fact that specimens were collected and observed only in the higher portions of the gebel near Rumia is a direct result of my efforts having been concentrated there and does not indicate that gundis are most abundant at higher elevations or that they do not occur at lower elevations.

Near Cussabat, gundis were abundant in the rocky hillsides of the easternmost limits of the Gebel Nefusa. The escarpment here is lower in elevation and more gradual in slope, and rocky areas are more sporadic and localized. A large series of gundis was obtained from the ledges and rocky outcroppings near the valley floor. Vegetative cover was denser here than at Rumia and consisted primarily of clumps of perennials scattered among the rocks and cliffs.

Vegetative cover among the rocks and boulder fields, although never dense, is surprisingly uniform. Several species of succulent, herbaceous perennials are widespread in these rocky areas, but grasses are almost always the dominant type of vegetation. Freshly cut stems and leafy portions of these plants, mingled with fecal droppings, were frequently observed on rocky ledges and beneath boulders and indicated the presence of gundis in a given area.

Hunting these animals with a shotgun proved to be the most effective method. They are usually extremely wary and appear for only short periods of time in the sunlight or in the shaded recesses of large rocks, rocky ledges, and projections. On one occasion on the gebel near Rumia, three gundis were shot in rapid succession, each one appearing on the same rocky ledge as its predecessor after the latter had fallen dead into a nearby crevice. Presumably these rodents are exclusively diurnal and reach a peak in their activity during the hours of midmorning after the sun's rays have warmed the ledges and feeding stations. They seem to have a secondary surge of activity in the late afternoon after the heat of the day has subsided. In the middle of the day, when maximum temperatures prevail, they remain in the sanctuary of their nests in crevices and fissures of the rocky outcroppings.

Even though the gundis near Rumia were collected in late winter (early March), daytime temperatures reached 98° F and, at night,

did not drop below 45° F. At Cussabat, which we visited during early summer (late June), the maximum daytime temperatures were even higher and exceeded 100° F, and at night the minimum temperature was 57° F. The relative humidity, for the two days spent at Cussabat, was 72 and 70 percent respectively. To what extent these high temperatures and the high humidity influenced the behavior of the gundis is not known, but certainly the high daytime temperatures induced them to remain more inactive during the middle of the day.

Gundis do not share these rocky habitats with any other species of large rodent, but near Rumia, several specimens of *Gerbillus campestris* were taken from traps set among rocky outcrops known to contain gundis, and at Cussabat, an elephant shrew (*Elephantulus* Thomas and Schwann) was obtained from a rocky surface over which gundis frequently travelled.

A skull of a young female, 325855, from near Cussabat, shows two distinct bregmatic bones in the middorsal region near the frontoparietal suture.

In general appearance, habits and habitat preferences, the gundi resembles the pikas of the genus *Ochotona*, which are entirely unrelated and confined to temperate Asia and North America.

### *Ctenodactylus gundi vali* Thomas

*Ctenodactylus vali* Thomas, Proc. Zool. Soc. London, pt. 2, p. 11, October 1902 (Wadi Bey, northwest of Bu Ngem, Libya).

Specimens examined. One, from Wadi Bey, 45 km W Bu Ngem, Tripolitania.

Measurements. The external measurements of the above specimen, an adult female, 302296, are: Total length 178; length of tail ?; length of hind foot 38; length of ear 19. No cranial measurements are available.

Diagnosis. Entire pelage extremely long, fluffy and silky, Light Pinkish Cinnamon dorsally, uniformly suffused with brown and black-tipped hairs, and Light Buff ventrally with faint admixture of Warm Buff; characters of the facial region, fore and hind feet, and ear essentially as in *C. g. gundi*, but hind feet more nearly white dorsally and color of outer margin of pinna of ear darker and more nearly approaching that of the dorsal pelage. Skull: Similar in general shape and configuration to that of *C. g. gundi* but with markedly larger and more inflated mastoidal and audital portions of the auditory bulla, less flaring nasals anteriorly, and smaller infraorbital foramina.

Comparisons. For comparisons with *Ctenodactylus gundi gundi*, see account of that subspecies.

Remarks. Thomas, in 1902, described *Ctenodactylus vali* from the Wadi Bey near Bu Ngem, Tripolitania, and examined specimens from

the Wadi Titti, east of Socna. More recently, Toschi (1951) recorded a specimen from the Wadi Soffegin and assigned it to *C. g. vali*. Setzer (1957) recorded the most recent specimen of *C. g. vali* taken from the type locality at the Wadi Bey. These few specimens constitute the only known records of this subspecies in Libya.

The Wadi Bey is located about 300 kilometers southeast of the type locality of *Ctenodactylus gundi gundi*, but the range of *C. g. vali* probably includes most of the arid transitional desert between the Gebel es Soda and the coast. Most of the broad wadis in this region, which drain northward into the Gulf of Sirte, provide suitable habitat. The drier climate of these interior localities and the irregular scarps which are present on the margins of these wadis differ markedly from the more humid climate of the Gebel Nefusa and its higher and more imposing escarpments. The ranges of *C. g. gundi* and *C. g. vali* are thus physiographically and climatically distinct.

Gundis are unknown from the Gebel es Soda and the Gebel el Harug el Asued, both of which appear to have an abundance of suitable habitat. The Gebel es Soda is also only a short distance south of the Wadi Titti, a previous collecting site for the gundi. In the future, gundis will probably be found to occur in both of these areas.

Setzer (1957) stated that, during his visit to the Wadi Bey in 1955, his guide informed him that in the past numerous gundis had inhabited the "broken rock scarps" but owing to a severe drought the vegetation had dried up and most of the gundis had died.

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Coastal plain near Tocra showing typical habitat of *Microtus mustersi* and *Mus musculus*, May 1962.

Broad coastal plain 20 kilometers east of Tobruch, Cyrenaica. The densely vegetated hummocks provide ideal habitat for the large Egyptian jerboa (*Jaculus orientalis*) and a small gerbil (*Gerbillus henleyi*), June 1962.

285-134 O—68——18

Bush-covered coastal plain near Tocra, Cyrenaica. *Gerbillus campestris* is the dominant rodent in this type of habitat, May 1962.

Coastal plain near Benghazi, Cyrenaica, showing characteristic hillocks supporting dense vegetative cover interspersed among bare, saline areas. The large Egyptian jerboa (*Jaculus orientalis*) and the Libyan jird (*Meriones libycus*) occur in this type of habitat, May 1962.

Fresh talus and burrow entrances of the sand rat (*Psammomys obesus*) in a large hummock on the coastal plain near Agedabia, Cyrenaica, May 1962.

Boulder-strewn slopes such as these of the escarpment near Gharian provide ideal habitat for gundis (*Ctenodactylus gundi*), March 1962.

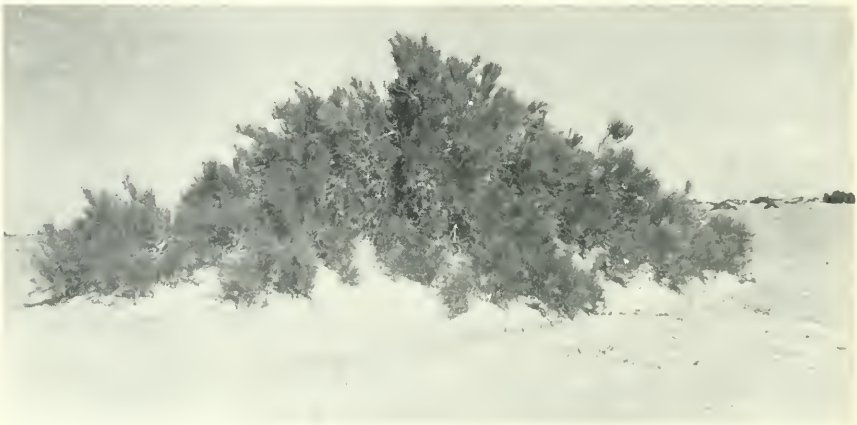
Rocky outcroppings and large boulders of the escarpment 5 kilometers west of Cussabat, Tripolitania, where a large series of gundis (*Ctenodactylus*) was obtained in June 1962.

Hamada (pebble desert), acacias, and escarpment approximately 100 kilometers west-southwest of Ubari, Fezzan. This "pebble desert" is the most characteristic type of terrain in the Libyan Sahara. Rodents occur sparingly in these "hamada" deserts and are usually represented by *Meriones crassus* or the ubiquitous *Gerbillus campestris*, December 1961.

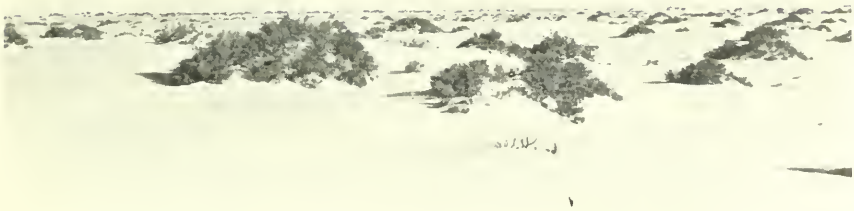
Bir bu Zarregh located near the "Cufra Track" in the desolate Sand Sea of Calanscio, Cyrenaica. Vegetation at this remote site consists of only three stunted date palms, a castor bean tree, and a eucalyptus tree. In spite of the isolated location of Bir bu Zarregh, jerboas (*Jaculus jaculus*) and gerbils (*Gerbillus gerbillus*) were found to occur there, March 1962.

Mounds of the mole-rat (*Spalax ehrenbergi*) on rocky slope north of El Faidia near the highest point of the Cyrenaican Plateau, May 1962.

Rock-strewn plain of the Gebel Nefusa, 12 kilometers south of Chicla, Tripolitania. The fat-tailed sand rat (*Pachyuromys duprasi*) prefers these areas where the surface is covered with coarse pebbles and the vegetative cover is sparse and localized, May 1962.



Large mound with dense cover of *Calligonum* near the oasis of Tazerbo, Cyrenaica. These outlying hummocks of the Saharan oases provide shelter and sustenance for several species of desert rodents, especially for jerboas (*Jaculus jaculus*) and gerbils (*Gerbillus gerbillus*), April 1962.



Vegetated dunes and sandy-clay hummocks supporting dense growths of *Tamarix* and *Calligonum* surrounding Tazerbo Oasis, Cyrenaica. These peripheral zones are inhabited by large numbers of jerboas (*Jaculus jaculus*) and gerbils (*Gerbillus gerbillus*), April 1962.

Dense pocket of *Phragmites* growing in an area of abundant fresh water near the oasis of Brach, Fezzan. A large series of *Mus musculus* was collected from the above habitat, February 1962.

Outlying tamarix near the oasis of El Gatrun, Fezzan. This peripheral zone of tamarix is typical of most of the larger oases in the Libyan Sahara and provides suitable habitats for several species of Saharan rodents, January 1962.

Date palms interspersed with sandy-clay hummocks supporting tamarix at El Abiad Oasis, Fezzan. The large gerbil, *Gerbillus pyramidum*, is abundant in the sandy areas around the palm trees where the dense, basal fronds afford shelter and the fallen dates provide a convenient source of food, December 1961.

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